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LOCAL RESPONSES TO REGIONAL AND GLOBAL CHANGES: THE
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TERRAMON REPORT SERIES No. 1
December 1992



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LOCAL RESPONSES TO REGIONAL AND GLOBAL CHANGES: THE SCIENTIFIC BACKGROUND TO TERRAMON

A. R. BERGER

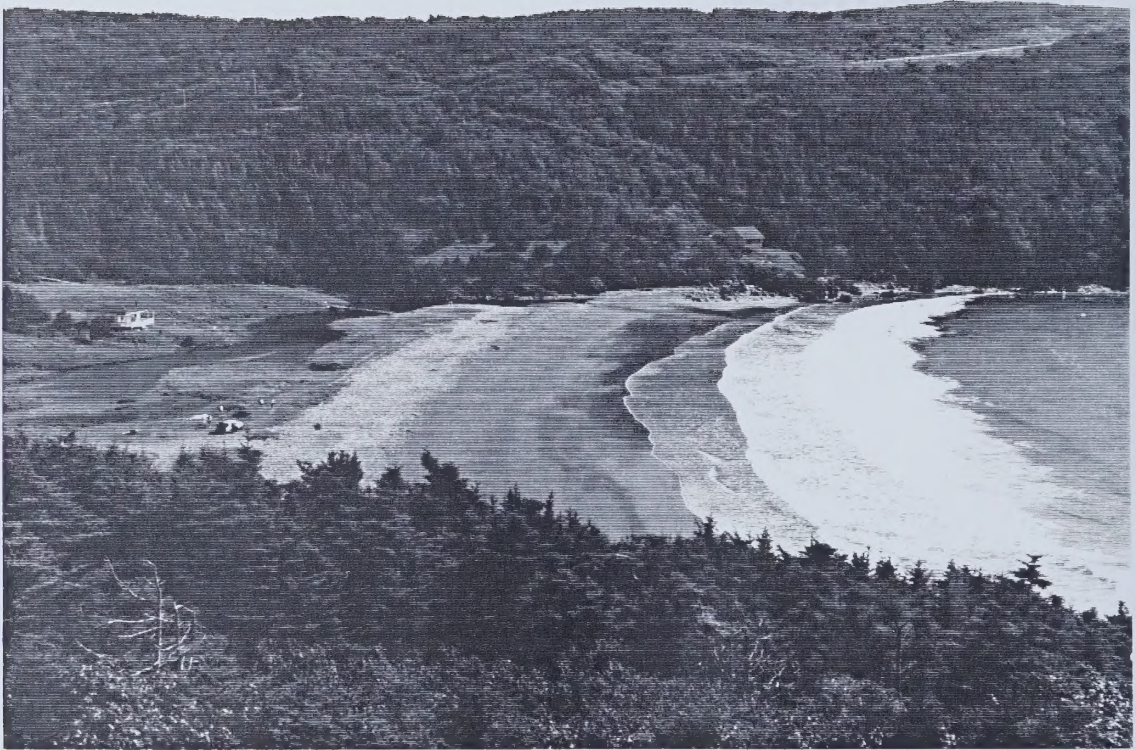
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**TERRAMON REPORT SERIES No. 1
December 1992**

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Gooseberry Cove, a tiny provincial park on the eastern shores of Placentia Bay. A small ecosystem amidst a forested portion of the Maritime Barrens Ecoregion, with a bayhead beach topped by windblown sand and deflecting a small stream. How does this and other distinct coastal systems respond to sea level fluctuations, coastal storms, and variations in sediment supply?

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LOCAL RESPONSES TO REGIONAL AND GLOBAL CHANGE: THE SCIENTIFIC BACKGROUND TO TERRAMON

PREFACE

This report describes the scientific and organizational background to TERRAMON, a new cooperative multi-agency network to support and strengthen long-term environmental research and monitoring in Newfoundland and Labrador. Because of the importance of protected areas in providing undisturbed sites, much of this report is devoted to a discussion of the opportunities for repeated and long-term observations and studies in parks and wilderness and ecological reserves. Ecological and biological parameters may be the key environmental indicators, but it is also important to consider dynamic aspects of the bedrock, soils and landforms even in the absence of obvious living matter. A survey is included of relevant environmental monitoring now being carried out in the province, certain gaps are identified, and a review is made of linkages, actual and potential, with existing regional, national and international organizations and programs dealing with aspects of environmental change.

ACKNOWLEDGEMENTS

This study owes much to the initial enthusiasm of Jon Lien and the Protected Areas Association. The Canadian Parks Service and the provincial Parks Division provided support for the initial field survey of Newfoundland's protected areas. TERRAMON itself would not have materialized were it not for the agreement of the Centre for Earth Resources Research at Memorial University of Newfoundland, and Jeremy Hall, its Director, to coordinate and develop the general concept. Helpful suggestions on earlier drafts of this report came from David Liverman, John Gibson, Peter Scott, Glen Ryan, Stuart Porter, John Kingston and Don Forbes. Finally, I acknowledge with gratitude the encouragement and advice of the TERRAMON Advisory Committee and of Neil Munro, Don Lockwood and Jeremy Hall.

THE BACKGROUND

The Need to Understand Long-Term Environmental Change

The recent moratorium on the cod fishery off the east coast of Newfoundland and Labrador raises many fundamental scientific questions. Were human actions such as overfishing, the extensive use of gill nets, and extensive bottom trawling the cause for declining stocks? Are there unknown, even chaotic, natural processes at work? Can codfish in abundance disappear from our waters as suddenly as they increased and declined elsewhere in the past, and for similar reasons?

What will the future landscape and biota of the province look like in comparison to the present and the past? If the climatic and other regional and global changes now forecast do materialize, what will the long-term effects be? To assess how the land and its biotic communities may have changed, future generations - citizens, planners and policy makers alike - will require detailed information on today's environments. Indeed, if such information on the environment of the past century or decades were now available, a clearer separation of natural and anthropogenic processes would presumably be possible. Newfoundlanders should be in a much better position to understand the current crisis in the cod fishery, and exactly what the effect of human-induced stresses has been.

As general concern grows about possible climatic and other global environmental changes, the need for long time-series data on surface phenomena and processes that affect the geosphere and the biosphere is becoming more and more obvious (IPCC, 1990)¹. To establish a baseline against which future environmental sustainability and change can be assessed many kinds of information are needed. These include data and models of biodiversity, past and present weather patterns, sedimentation and erosion rates, forest succession, and air and water chemistry. Moreover, interdisciplinary studies must be continued systematically into the future, so that 50 or 100 years from now it will be possible to determine precisely what environmental changes have taken place.

To manage the environment effectively a better distinction will also have to be made between changes in environmental factors (e.g. atmospheric composition, distribution of fauna and flora, surface temperature, sea levels) that would have taken place in the normal evolution of nature without interference by human activities and those that are a direct or indirect result of forcing by society. What natural events have contributed to the present landscape and biota, and what

¹ For example the draft text for the international agreement on Biodiversity signed at the recent Rio conference referred to the need to "undertake long-term research into the importance of biodiversity for the functioning of ecosystems and the role of ecosystems in producing goods, environmental services and other values supporting sustainable development."

does their past history tell us about trends into the future? What are the effects of human activities, both near and far, upon the natural environment (Figure 1)? And how can environmental research and monitoring² in Newfoundland and Labrador assist in understanding environmental changes elsewhere in North America, and on a global scale?



Figure 1 - ATV track across the Hawke Hill Ecological Reserve. What is the long-term ecological effect of such marks and what can be learned in terms of small-scale environmental sustainability from monitoring their appearance?

² Monitoring is the making of repeated observations over time of natural features and parameters, such as specific organisms, populations, landscape elements, or surface water chemistry. Although it is an essential part of much research, monitoring is associated commonly with the "mindless" collection of data. For this reason, this report (and the TERRAMON network) uses both terms monitoring and research, recognizing that many years of patient and unrewarding observations may be required to collect enough data to define a trend.

Environmental issues and "wicked" problems are generally much more difficult to define because they deal with many components - physical, biological, social, than "tame" problems of science that can be set within recognizable boundary conditions. They cannot be resolved using narrow, single-purpose approaches, but require holistic research efforts that cross traditional disciplinary boundaries. These are severely hampered by (1) the structural barriers set up by the prevailing system of education, (2) the preference of scientists for the "corporate" approaches, paradigms and information networks of their own fields, (3) the bias against multi-authored publications, and (4) the compartmentalized and sectoral character of government and academic institutions (di Castri and Hadley, 1992).

Responding to the Challenge

Many international programs have recently been established to provide the scientific background for understanding global change (Risser, 1991). These include the Global Environment Monitoring System (GEMS) of the United Nations Environment Programme, the International Geosphere-Biosphere Programme (IGBP) of the International Council of Scientific Unions, the World Climate Research Programme (WCRP) sponsored jointly by ICSU and the World Meteorological Organization, and the Man and the Biosphere Programme (MAB) of Unesco.

On a national level in this country there are, for example, the Canadian Global Change Program run by the Royal Society of Canada, and the paleoenvironment and global change programs of the Geological Survey of Canada. A national network for monitoring ecological areas is being planned by Environment Canada.

A common emphasis in these programs is on the collection of baseline data and the production of models, such as of global atmospheric and oceanic circulation, ecosystem development, and geochemical fluxes between land, air and sea. Calibration of these models requires realistic data, and there are many specific experiments and research projects now being designed for this purpose (Mooney et al., 1991).

A group of federal, provincial and academic organizations agreed in late 1991 to set up a cooperative mechanism called **TERRAMON**³ to facilitate long-term monitoring and research on environmental change in Newfoundland and Labrador. The goal is to assist in providing the key information required for proper understanding, planning and management of the natural environment of the province, for effective control of protected areas, and for State of the Environment Reporting.

³ "Monitoring Terra Nova"

The Role of Protected Areas

Ideally, long-term research and monitoring would be carried out wherever scientific or policy needs dictate. For example, sites for repeated study of the changes in chemistry of a key river or the species composition of a unique vegetation community would be established as convenient. However, there is little use setting up long-term monitoring in sites that can be disturbed or even destroyed by developments such as roads, dams, exploration camps or logging⁴. The problem of site security in Newfoundland and Labrador may not be as severe as in more densely populated regions, and certainly there are already some valuable long-term monitoring sites outside protected areas in the province. The on-going fish habitat study (since 1984) of the Department of Fisheries and Oceans (DFO) in unprotected but relatively remote rivers of the southeastern Avalon is but one example. Nevertheless, a first requirement for the collection of long time-series data is continuing financial and administrative stability and site security of the sort that requires firm commitment by governments.

After the original scientists involved pass from the scene, the monitoring experiments they establish must be picked up, and modified as necessary, by successive generations of scientific workers. A second requirement, therefore, is the availability into the future of scientifically trained and environmentally sensitive personnel who would continue monitoring experiments and data collection, and who could understand and interpret the results in terms of their future environment.

These two conditions are met by national and provincial parks, world heritage sites, and other areas protected by law and by public demand (e.g. Berger, 1992; Comanor and Dennis, 1992). In these places human intervention is and will continue to be controlled to one degree or another, and for most there will continue to be management structures and personnel in charge⁵. In selecting natural ("ecological") areas for protection, their value for scientific research is commonly taken into account, though this may be regarded as secondary in importance to considerations of representation and function (Beechey, 1989). Even if this is not a main consideration in protecting a particular area, scientific research itself (e.g. each additional year

⁴ Keddy (1989) describes a situation where some 5 years of painstaking long-term experiments on wetland ecology in Ontario were very nearly ruined when a local land-owner gave his team 24 hours to get their experiments off his land.

⁵ The 4th World Congress on National Parks and Protected Areas meeting in February, 1992, issued "The Caracas Declaration" affirming the "belief in the vital importance of well-managed national parks and protected areas to all people." Governments and "appropriate national and international bodies" were urged "to foster publicly funded scientific research and monitoring that will improve the planning and management of protected areas, and to use such areas as sites for studies that will improve understanding of the environment" (quoted in Canadian Biodiversity, vol.2, #2, 1992).

of data) enhances the value of a protected area (Keddy, 1989). What is needed, therefore, is to ensure that a scientific dimension is added to protected areas. The resulting data will aid in both the understanding of global and regional change, and in natural environmental education and management.

Any effective research and monitoring program will also have to consider environmental changes to unprotected rural and wilderness landscapes, to urban areas, and even to near-shore and off-shore areas. Nevertheless, for the reasons stated above, the focus in this report is on the protected areas (PAs) of Newfoundland and Labrador.

TERRAMON

Developing An Approach for Newfoundland

The possibility of setting up long-term monitoring observations in Gros Morne National Park (Figure 2) was first raised with park staff in 1988, and several proposals to this effect were circulated to officials of the Geological Survey of Canada and the Canadian Parks Service in 1989 and 1990. In late 1990, the St. John's-based Protected Areas Association (PAA) suggested expanding the concept to all protected areas in the province.

With funding to PAA from the Economic Recovery Commission and the Canadian Parks Service, a rapid field survey of most of the protected areas (PAs) on the island was carried out in the summer of 1991 to assess their general suitability for long-term environmental studies (Berger, 1991). For most PAs, the survey attempted to define environmental parameters significant for monitoring, and to identify current, planned and completed research and data sets, interested scientists, relevant agencies and organizations.

To identify research relevant to environmental change in the province, interviews were carried out throughout 1991 and into 1992 with a wide range of scientists, as well as with officials of the various federal and provincial agencies responsible for protected areas and engaged in one aspect or another of environmental monitoring. Potential linkages have also been identified with various national and international programs dealing with global and environmental change.

General support for a provincial environmental monitoring system, TERRAMON, was expressed at an open forum at Memorial University organized by the Centre for Earth Resources Research (CERR) in May, 1991. The results of the field survey were presented in St. John's, Newfoundland, on November 14, 1991, to university scientists and representatives from federal and provincial agencies, at which general approval was given to set up a new cooperative, multi-disciplinary organization called TERRAMON, to be coordinated by the Centre for Earth Resources Research (CERR) at Memorial University, St. John's. The overall goal is to assist

in providing the key information required for proper understanding, planning and management of the natural environment of the province, for effective control of protected areas, and for State of the Environment reporting.

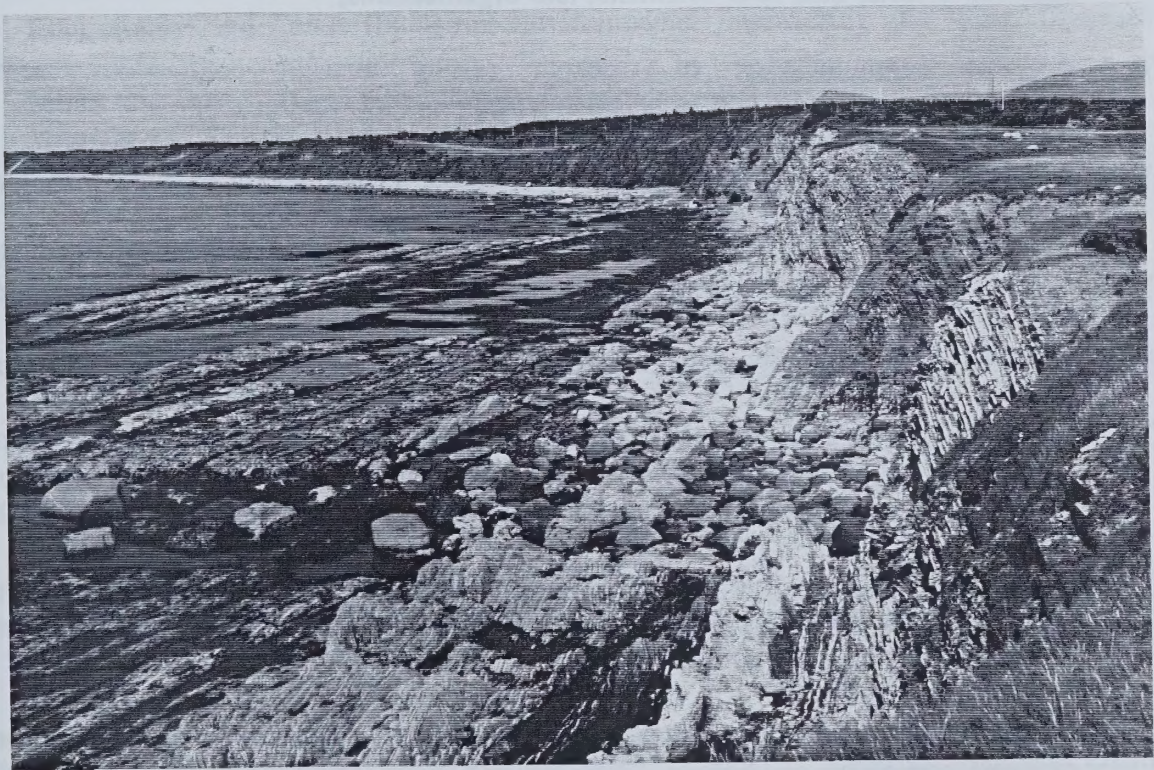


Figure 2 - Green Point, Gros Morne National Park. How stable are these intertidal platforms? Are the boulders still moving, and at what rates? Or were they moved to these positions during the fast-changing environment that followed the recession of the last Pleistocene ice from this coast? How sensitive are intertidal communities along this and other rocky shores of Newfoundland and Labrador?

TERRAMON - Objectives, Activities and Priorities

The Advisory Committee set up by CERR and composed of representatives of various supporting agencies (Table 1), has established that the objective of TERRAMON is to **facilitate long-term monitoring of and research on environmental change in Newfoundland and Labrador.**

In pursuit of its goal TERRAMON will, as resources permit:

- 1) establish a network among the various groups and individuals engaged in studying environmental change in Newfoundland and Labrador;
- 2) compile and maintain an inventory and referral database on relevant study sites, research efforts, data sets, scientists, and organizations;
- 3) promote communication of research results through conferences, seminars, workshops, newsletters and technical reports;
- 4) encourage new research directions and monitoring techniques for example through short courses on GIS, dendrochronology and lichenometry;
- 5) provide advice on key sites, parameters, scales and studies for monitoring and research;
- 6) promote and support new studies and the integration of existing information and data sets;
- 7) link with international, national, and local efforts related to global and environmental change (such as the Model Forest Project in western Newfoundland), thereby raising the profile of Newfoundland and Labrador in global change research;
- 8) provide background data and information for planners, policy makers and others concerned with the management of the environment, including those responsible for State of the Environment Reporting;
- 9) identify opportunities for enhanced economic activities related to the natural environment of Newfoundland;
- 10) enhance public awareness of the requirements for environmental sustainability.

Table 1 - TERRAMON Advisory Committee Members (as of September, 1992).

Federal Agencies

Agriculture Canada (Research Branch)
Energy, Mines and Resources (Geological Survey of Canada)
Environment Canada (Atmospheric Environment Service, Canadian
Parks Service, Environmental Protection Service)
Fisheries and Oceans (Science Branch)
Forestry Canada (Newfoundland Forest Research Centre)

Provincial Agencies

Environment and Lands (Industrial Environmental Engineering and Water Resources
Management Divisions)
Mines and Energy (Geological Survey Branch)
Tourism and Culture (Parks and Wildlife Divisions)

Academic Organizations

Memorial University of Newfoundland (Biology, Chemistry, Earth Sciences, Geography,
Labrador Institute of Northern Studies, Ocean Sciences Centre, Psychology)
West Viking College (Centre for Forestry and Environmental Studies)

Coordinating Agency

Centre for Earth Resources Research (CERR), Memorial University of Newfoundland

Despite the paucity of protected areas and the many unresolved conflicts over land claims, Labrador is the current focus for a Labrador Ecosystems Analysis Facility (LEAF), being proposed by Memorial University's Labrador Institute of Northern Studies. This would facilitate and support a wide range of environmental research, especially on Labrador's wildlife, and there would be many opportunities for close cooperation with TERRAMON. The Canadian Parks Service is proposing to establish new national parks in the Torngats and the Mealy Mountains: these could offer significant opportunities for long-term research and monitoring.

In terms of spatial priorities, TERRAMON will, as far as resources permit, extend its attention

(i) to terrestrial environments then to near-shore and then to marine; (ii) to protected areas and existing intensive monitoring sites and then to non-protected areas; and (iii) to the Island of Newfoundland and then to Labrador.

In terms of a temporal focus, the major research efforts will concentrate on the present environment and its character for the next 50 to 100 years, with close attention paid to the environments of the past 500 years. However, in order to establish long-term trends, research is also required on paleoenvironments during earlier periods of aboriginal settlement (500-5,000 years), back to the time of major post-glacial recovery (5,000-10,000 years), and to even earlier periods, such as Pleistocene interglacials.

The TERRAMON Database

Much of the information collected in the 1991 field survey and subsequently is stored in digital form in the TERRAMON Database, which in late 1992 is still being modified and expanded. This database provides background information needed to facilitate long-term research on and monitoring of the natural environment of the province, within the general context of regional and global environmental change. It is designed to answer the questions

- "Who is doing what scientific research on the environment, and where?"
- "What data sets exist on the natural environment?"
- "What natural areas are protected and what opportunities do they provide for scientific research on the environment?"

The Database is both a referral tool (e.g. to datasets and key literature) and a source of original information on some protected areas. As illustrated in Table 2, it consists of four sections, interrelated by a common set of keywords on:

- databases and data sets;
- protected areas;
- organizations and programs involved in environmental research, and;
- key documents and publications relevant to environmental monitoring in protected areas.

The first three sections are believed to be reasonably complete, but the fourth section contains only a sampling of the scientific literature and documentation on the province's protected areas. A fifth section listing active scientific researchers will be added later.

The database uses Q&A (Version 4), a popular quasi-relational database management system

which permits elaborate but user-friendly searching. Data can be exported easily to and from dBase, PARADOX, 123, and in ASCII and DIF formats. Public access to the database is being arranged through Queen Elizabeth II Library at Memorial University.

Current Scientific Knowledge of Newfoundland's Natural Environment

A very rough indication can be presented of the current knowledge of the natural (non-urban) environment in Newfoundland and Labrador, using the information in the TERRAMON Database. One indication may be obtained from the list of 129 formal databases and informal data sets that currently include scientific data on one aspect or another of the environment, as broadly defined (Appendix 1). In terms of numbers of databases, the obvious strengths are in the areas of chemistry, geology, climatology, hydrology, oceanography and on coastal environments. Databases on ecology and on the flora and fauna (botany and biology) are much less numerous, though there are 11 dealing with birds.

Another rough measure of the range of environmental work can be obtained from the list of some 35 agencies and programs (mainly governmental) now working on one aspect or another of the environment of Newfoundland and Labrador (Appendix 2). The relative paucity of ecological and biological activities can again be seen. Among these agencies, Environment Canada's Atmospheric Environment Service collects weather data from a large number of sites on the Island, including stations in Gros Morne, Salmonier, and Port au Choix. Stream flow and water quality records are kept by Environment Canada's Water Resources Branch and the Newfoundland Department of Environment and Lands for many river basins, some of which include PAs (Beothuck, Crabbes, Gros Morne, Pipers Hole River, Stag Lake, Terra Nova).

The Department of Fisheries and Oceans collects data on aquatic biota in ponds in Gros Morne as part of a wider program related to long-range transport of acid particulates (LRTAP), and on selected river basins in the souther Avalon. The Geological Survey of Canada is monitoring sedimentation and erosion along some parts of the coastline, and personnel from Memorial University's Geography and Biology departments are studying changes in vegetation within Terra Nova National Park.

No thorough bibliography yet exists of the voluminous literature on one aspect or another of the natural environment of Newfoundland. Meades' comprehensive (1990) report to PAA on the natural regions of the province cited over 400 publications and journal articles. Depending on how the term "environment" is defined, the real number of publications and unpublished reports could be well into the thousands.

PROTECTED AREAS OF NEWFOUNDLAND AND LABRADOR

A Spectrum of Protection

The protected areas of the province set aside a wide variety of landscapes, ecosystems, and biotic communities. These range from forests to wetlands, peatlands, heaths, lakes and ponds, rivers and streams, coastlines, mountains, and an assortment of barrens. Apart from Crown Lands, some 466 terrestrial areas in Newfoundland and Labrador are protected in one form or another under provincial or federal regulations. Figure 3 shows the locations of all provincial parks, and wilderness and ecological reserves in the province. A summary of the various categories is given in Table 3. This includes some sites identified as potential biosphere reserves by the International Biosphere Programme (IBP) in the 1970's (Anon, 1974), and which are still protected to some degree as Crown Land Reserves. A very useful "Atlas" and inventory of many of these PAs, together with a commentary on the degree of protection provided is being prepared for publication by the PAA.

There are several ways to judge the degree of security offered by particular PAs. A widely used international standard for ranking areas by degree of protection is that developed by the International Union for the Conservation of Nature (IUCN). This uses a classification structured according to the degree of human intervention and the management objectives (see Eidsvik, 1992). However, there does not yet appear to be a satisfactory application of this scheme to Newfoundland and Labrador. Environment Canada's Natural Conservation Areas Data Base (NCADB - see Turner et al., 1992) does assign IUCN categories to 98 Newfoundland and Labrador PAs, but it is difficult to understand the rationale for this classification (see Table 4).

In a report to the Canadian Council on Ecological Areas (CCEA), Peterson and Peterson (1991) define a protected area as "any land-use designation in which protection is provided to the degree necessary to exclude: logging; hydroelectric development; cut-lines; seismic shot-hole sites; cleared access routes, and other forms of disturbance associated with mineral and petroleum exploration and development." This definition focuses on human disturbances, but would exclude, for example, Gros Morne National Park, which permits controlled tree-cutting in designated areas.

The CCEA (1992, p.1) itself now uses the term **protected areas** to refer to "all government-owned properties (IUCN categories I-IV) contained in the National Conservation Area Data Base". Protected "ecological areas" are defined more closely as "formally protected areas established to maintain viable examples of Canadian ecosystems, flora and fauna to preserve natural diversity and to provide opportunities for scientific research, environmental education

Table 2 - Structure of the TERRAMON database.

TERRAMON DATABASE

INDEX

Record Number
Date Record Added/Updated
Keywords

DATA SETS

Name
Purpose
Coverage
Description
Length of Record/Update Frequency
Format
Data Type/Variables Measured
Location
Contact Person
Mailing Address
Telephone
Fax

PROTECTED AREAS

Name
NF/LB
General Location
NTS
Lat/Long
PA Category
Ecoregion
Date Protected
Area (ha)

PROTECTED AREAS (cont'd)

Contact Person
Comments
Man-made Problems
Natural Problems
To Monitor
Notes

ORGANIZATIONS AND PROGRAMS

Name
Address
City
Province/State
Postal Code
Country
Phone
Fax
Contact Person
Facilities
Activities

KEY DOCUMENTS

Author
Title
Year
Pages
Where Published
Notes

Figure 3 - Provincial Parks, Wilderness and Ecological Reserves (1992 Map courtesy of Provincial Parks Division).

PROVINCIAL PARKS, WILDERNESS AND ECOLOGICAL RESERVES

Arches - 306	Indian River - 301
Aspen Brook - 212	Jacks Pond - 116
Avalon Wilderness - 220	Jiggin Head - 129
Backside Pond - 112	Jipujijkuei Kuespem - 213
Baie Verte - 302	Jonathans Pond - 205
Barachois Pond - 407	La Manche - 102
Bay du Nord - 220	Lockston Path - 121
Bellevue Beach - 115	Maberly - 132
Beothuck - 211	Marine Drive - 128
Black Bank - 406	Mary March - 214
Blow Me Down - 401	Middle Cove - 127
Blue Ponds - 403	Mistaken Point - 136
Bottle Cove - 402	Mummichog - 411
Butter Pot - 104	Northeast Arm - 216
Cape St. Mary's - 135	Northern Bay Sands - 114
Catamaran - 218	Notre Dame - 207
Cataracts - 107	Otter Bay 413
Chance Cove - 101	Pasadena Beach - 315
Cheeseman - 412	Pearsons Peak - 215
Cochrane Pond - 103	Piccadilly Head - 405
Codroy Valley - 410	Pinware River - 310
Crabbes River - 408	Pipers Hole River - 124
Deadman's Bay - 204	Pistolet Bay - 309
Dildo Run - 209	Point au Mal - 404
Dog Bay Pond - 210	Point La Haye - 108
Duley Lake - 311	Rattle Falls 130
Dungeon - 131	River of Ponds - 307
Eastport North - 217	Salmon Cove Sands - 113
Father Duffy's Well - 106	Sandbanks - 414
Fitzgeralds Pond - 111	Smallwood - 303
Flatwater Pond - 303	Smith Sound - 120
French Islands - 133	Sops Arm River - 305
Frenchmans Cove - 118	Southwest Pond - 126
Funk Island - 221	Square Pond - 201
Gannet Island - 319	Squires Memorial - 304
Glenwood - 206	Stag Lake - 415
Gooseberry Cove - 110	Table Point - 318
Grand Lake - 312	Thorburn Lake - 119
Grand Codroy - 4	Three Mile Lake - 308
Gushues Pond - 105	Watts Point - 320
Hare Bay - 317	Windmill Bight - 203
Holyrood Pond - 109	Winter Tickle Lake - 219
Indian Cove Neck - 208	Witless Bay Islands - 137

PROVINCIAL PARKS

1992

Regions under Provincial Park System

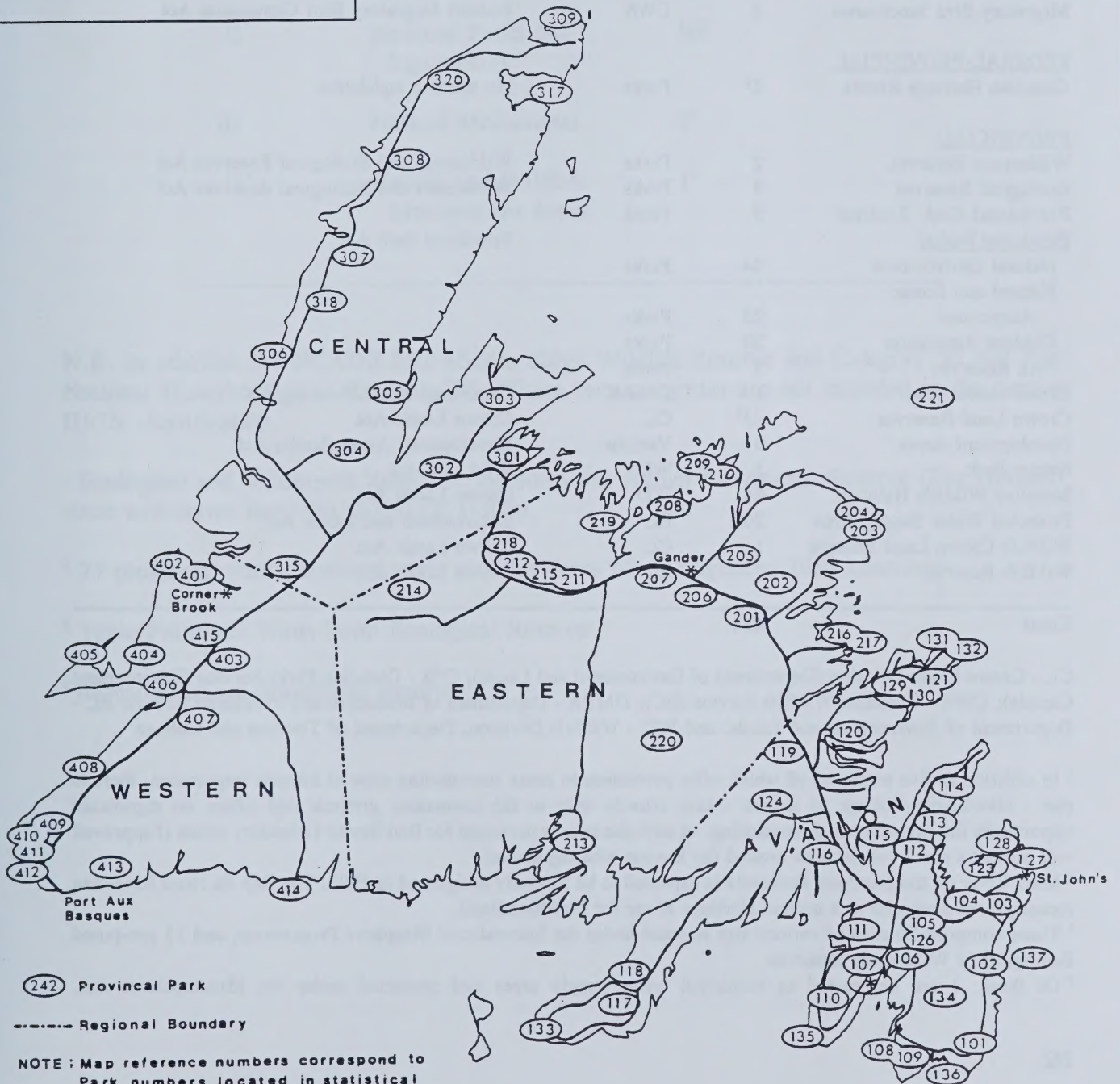
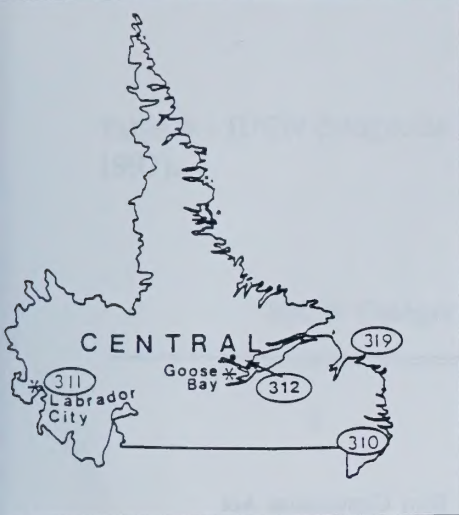


Table 3 - Protected Areas of Newfoundland and Labrador.

PROTECTED AREAS			
Category	#PAs	Responsible Agency	Protected Under
<u>FEDERAL</u>			
National Parks	2	CPS	National Park Act
National Historic Sites	5 ¹	CPS	National Park Act
Migratory Bird Sanctuaries	2	CWS	Federal Migratory Bird Convention Act
<u>FEDERAL-PROVINCIAL</u>			
Canadian Heritage Rivers	2 ²	Parks	No specific legislation
<u>PROVINCIAL</u>			
Wilderness Reserves	2	Parks	Wilderness and Ecological Reserves Act
Ecological Reserves	8	Parks	Wilderness and Ecological Reserves Act
Provisional Ecol. Reserves	5	Parks	Provincial Park Act
<u>Provincial Parks:</u>			
Natural Environment	34	Parks	
Natural and Scenic Attractions	20	Parks	
Outdoor Recreation	20	Parks	
Park Reserves	5	Parks	
Conservation Area	1	DMPA	Urban and Rural Planning Act
Crown Land Reserves	43 ³	CL	Crown Lands Act
Development Areas	3	Various	Development Areas (lands) Act
Nature Park	1	WD	Wild Life Act
Sensitive Wildlife Habitats	64	WD	Crown Lands Act
Protected Water Supply Area	202	EL	Environment and Lands Act ⁴
Wildlife Crown Land Reserve	1	CL	Crown Lands Act
Wildlife Reserve	1	EL	Crown Lands Act
Total	422		

CL - Crown Lands Division (Department of Environment and Lands); CPS - Canadian Parks Service (Environment Canada); CWS - Canadian Wildlife Service (EC); DMPA - Department of Municipal and Provincial Affairs; EL - Department of Environment and Lands; and WD - Wildlife Division, Department of Tourism and Culture

¹ In addition to five areas, all of which offer protection to areas surrounding sites of historic importance, there is one - Hawthorne Cottage in Brigus - that extends only to the immediate grounds and offers no significant opportunity for environmental monitoring. A new site is now proposed for Red Bay in Labrador, which if approved will protect a small coastal area around the Basque whaling station.

² Main River on the Northern Peninsula is expected to be formally designated in 1993. The Bay du Nord River has recently been proposed as a second Heritage River for Newfoundland.

³ These comprise 26 sites of various size selected under the International Biosphere Programme, and 13 proposed Ecological or Wilderness Reserves.

⁴ Of these, 3 are designated as municipal water supply areas and protected under the Municipalities Act.

Table 4 - IUCN categories for some Newfoundland protected areas (according to the NCADB, 1992).

IUCN Category	Protected Areas	Number in Newfoundland
I	Scientific Reserves Wilderness Areas	10 ¹
II	National Parks and Equivalents	80 ²
III	Natural Monuments	3 ³
IV	Habitat and Wildlife Management Areas	1 ⁴

N.B. In addition the NCADB lists Middle Ridge Wildlife Reserve and Category VI and four National Historic Sites as Category XI. These two categories are not included in the current IUCN classification.

¹ Ecological and Wilderness Reserves, including one former Provisional Reserve (The Grasses) since withdrawn from the provincial system.

² 77 provincial parks, national parks and the Terra Nova Migratory Bird Sanctuary.

³ Table Point and Watts Point Ecological Reserve

⁴ Baccalieu Island Ecological Reserve

and appreciation" (Beechey, 1989, p.1)⁶.

Reviewing the province's PAs in terms of the legislation and regulations that protect them, the PAA Atlas now being prepared uses the following grouping:

- | | |
|--------------------------|--|
| "Fully Protected" | - Wilderness and Ecological Reserves
- National Parks ⁷ |
| "Partially Protected" | - Provincial Parks
- Provincial Wildlife Reserves ⁸
- Federal Migratory Bird Sanctuaries |
| Other areas ⁹ | - Crown Land Reserves
- Park Reserves
- Provisional Ecological Reserves
- Protected Water Supply Areas
- Development Areas
- Conservation Areas |

This is backed up by a succinct review of each relevant act of legislation in terms of (1) the steps required to protect new areas, (2) the selection criteria used, (3) the administrative agency, (4) permitted activities, (5) the degree of natural area protection afforded, and (6) the ease with which the status of a PA can be changed.

In practical terms, many of the national parks and historic sites have year-round resident staff to patrol and regulate human activities. However, there are none in the ecological and wilderness reserves, apart from temporary staff at Cape St. Mary's during summer months. On the other hand, many of the provincial parks have staff on-site during the summer months to provide a measure of protection, but the legislation protecting them is very much weaker than the very strong piece of legislation under which Wilderness and Ecological Reserves operate. The numerous crown land reserves and protected water supply areas are subject to many human interventions, not all permitted. **Nevertheless, most if not all PAs appear to offer the potential for up-grading of their legislative and administrative protection, if required for**

⁶ A listing for Newfoundland and Labrador obtained in mid-1992 from the CCEA's own National Registry of Ecological Areas included only 13 such areas, one of which (the Grasses) had earlier been dropped by the provincial government.

⁷ Included here might be National Historic Sites

⁸ Including the Salmonier Nature Park

⁹ This category should presumably also include Canadian Heritage Rivers.

long-term monitoring and research.

It should be noted that the vast majority of coastal PAs do not have jurisdiction seaward of the high tide mark. However, a small measure of protection for adjacent waters is potentially offered by the several seabird sanctuaries ranked as ecological reserves. The boundaries of the L'Anse Aux Meadows National Historic Site extend from the mainland shore of Sacred Bay to include several offshore islands, resulting in the inclusion of more than 4000 ha of coastal waters - making this in effect a partial marine park.

Spatial Distribution

The 390 or so PAs of Newfoundland and the 30 in Labrador are commonly grouped according to the ecoregion in which they are located. The standard ecological classification of Canada's land surface is derived from the work of Environment Canada in the late 1970's and early 1980's. This uses a hierarchy of terms ranging at the broadest scale from ecozones (15 for the whole country), descending through ecoprovince, ecoregion (177), ecodistrict, ecosection, ecosite to ecoelement. Each area is regarded as "a discrete system" arising from the "mesh and interplay of geologic, landform, soil, vegetative, climatic, wildlife, water and human factors" (Wiken, 1986, p.2). The island of Newfoundland falls entirely within the Boreal Shield Ecozone. Labrador contains portions of this and of the Taiga Shield, Southern Arctic and Arctic Cordillera ecozones (Figure 4).

The ecological land unit most commonly used in Newfoundland and Labrador is the **ecoregion**, defined by Environment Canada as "characterized by distinctive ecological responses to climate, physiography and hydrology as expressed by the development of vegetation, soils and fauna" (Turner et al., 1992).¹⁰ For the island of Newfoundland, there is as yet no provincially-approved classification, but general usage (Figure 5) follows the ecoregions and subregions by Damman (1983)¹¹. For Labrador an extensive classification based on a rather different concept

¹⁰ See S. J. Meades (1990) for a comprehensive review of the various land classifications of Newfoundland and Labrador.

¹¹ Damman (1983, p. 164) uses the term "ecoregion" as "an area within which the ecological relationship between species and habitat is basically similar. . . Thus, the ecoregion has a distinctive, recurring pattern of vegetation and soil development which is controlled by regional climate." Damman's subregions are equivalent to ecodistricts in the Environment Canada classification. There is some difficulty in locating Damman's eco-region and subregion boundaries because his original map was published on a large scale, and no accurate map showing these boundaries could apparently be found on a scale of 1:500,000 or smaller (see discussion in Taylor et al., 1991). Slight modifications to Damman's boundaries and

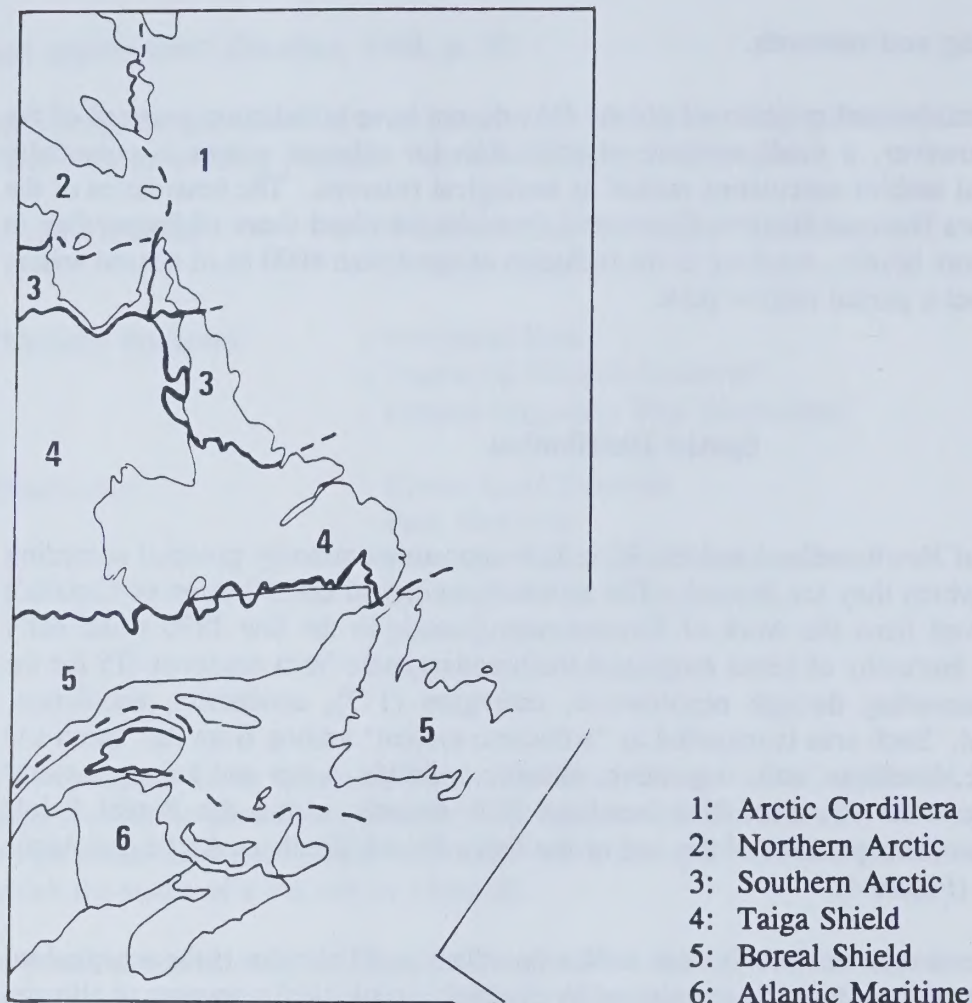


Figure 4 - Terrestrial ecozones of eastern Canada (from Wiken, 1986).

of ecoregions was published by Lopoukhine and others (1978). However, Meades has produced a simpler classification (Figure 6) much closer in principle to Damman's (W.J. Meades, 1989, unpublished - as quoted in S.J. Meades, 1990).

All of Damman's ecoregions are represented to one degree or another by protected areas (Table 5). However, apart from the inclusion of the southern part of the Long Range Barrens in Gros Morne National Park, this major ecoregion is not represented by an actual protected area. Four of Damman's subregions have no protected areas, and 2 others have only 1 each. For Labrador,

classification have been made by Wiken and others (1987) and by Meades and Moores (1989), and further changes will no doubt be required.

all of Meades' ecoregions are represented by at least one PA (as broadly defined in Table 3), but the level of protection afforded is generally low. There is only 1 ecological reserve (though 5 are proposed), and 2 provincial parks. However, extensive areas are set aside as crown land reserves, so that when land claims and other matters are settled there should be a rapid increase in protected areas here.

Mandates for Research

The mandates and policies that govern national and provincial parks acknowledge the importance of scientific research. For example, among the objectives of the provincial park system is one to "provide valuable scientific benchmark areas that can be used to measure and monitor environmental impact upon similar areas elsewhere" (Anon, 1988). Indeed ecological reserves at Fortune Head, Table Point and Mistaken Point, have been set up specifically to protect fossil sites of importance to researchers world-wide.

The currently proposed revisions to the Canadian Parks Policy recognize the use of national parks as benchmarks for ecological research (Anon, 1991; Woodley and Theberge, 1992). Scientific research will be permitted to monitor the past and present environment, and there is a clear recognition of the role of national parks in contributing to sustainable development concerns, for example through environmentally sound management. This research role does not, however, appear to be recognized for national historic sites and heritage rivers, many of which could also provide valuable sites for long-term study.

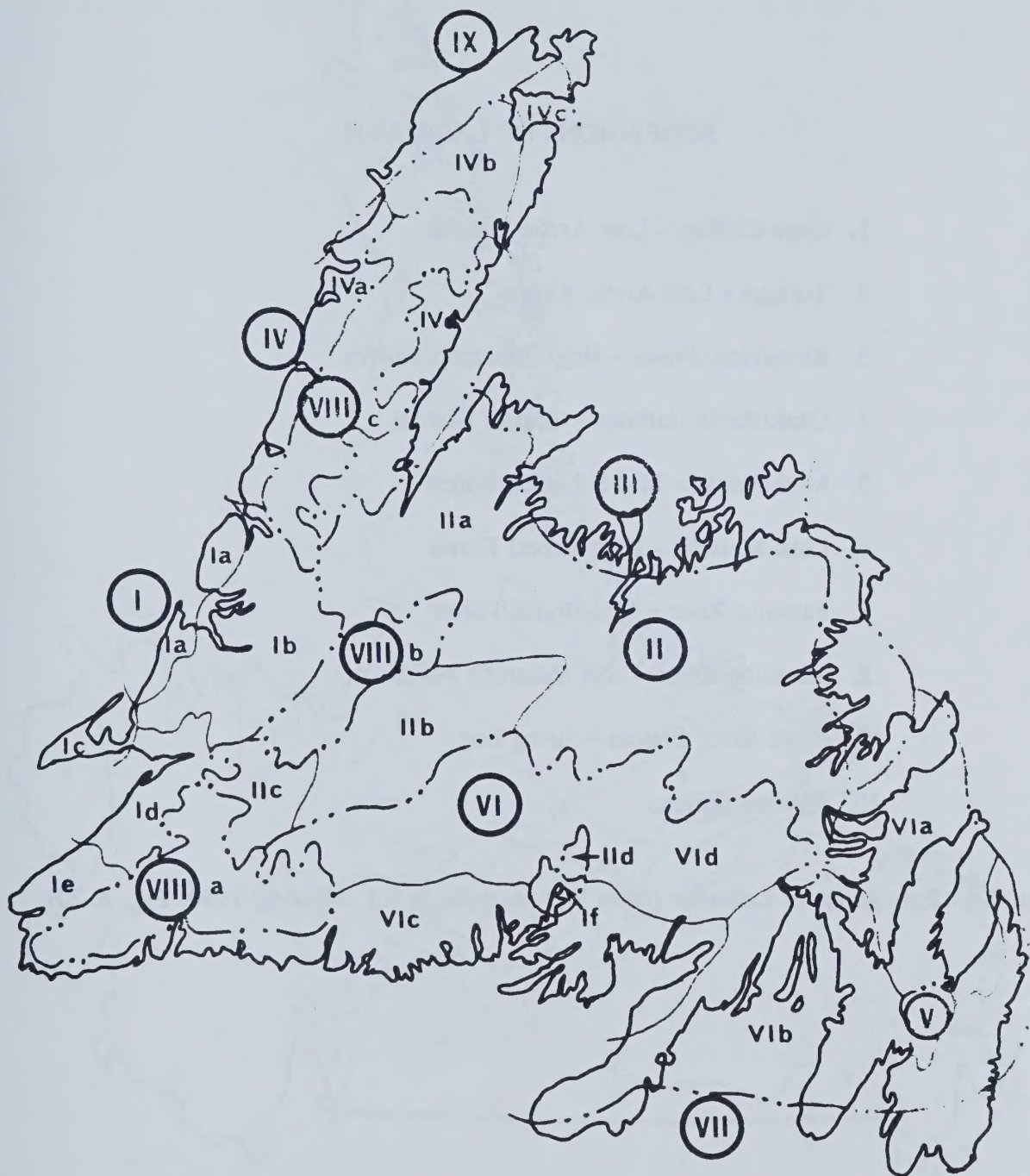
For example, the historic sites at L'Anse aux Meadows and Port au Choix protect substantial areas away from the archaeological sites that are their major concern. L'Anse aux Meadows may be the only protected area on the island of Newfoundland where palsas (permanently frozen peat mounds) occur: these features are sensitive to climate changes at the surface. Port au Choix protects a narrow coastal limestone barren that contains distinct flora and a variety of patterned ground that may be climate-sensitive. At both sites, archaeological studies have led to important findings concerning the paleoenvironment.

Some environmental monitoring is already being carried out in Newfoundland PAs, especially in the two National Parks. Examples include surveys of vegetation plots in Terra Nova, the chemistry of ponds and biotic communities in certain upland ponds in Gros Morne, coastal erosion and sedimentation in Sandbanks, Point La Haye, and Frenchman's Cove, wildlife dynamics in Salmonier and Avalon Wilderness, bird populations in Cape St. Mary's, Witless Bay and other seabird sanctuaries, forest insects and diseases in many PAs, and well and stream water quality in some provincial parks. Details are listed in the TERRAMON Database.

These activities represent only a small fraction of what needs to be done in order to compile an accurate picture of environmental change in Newfoundland. There is, for example, the potential to expand to key PAs current data-gathering programs such as the biomonitoring of rivers and

Figure 5 - Ecoregions and subregions of insular Newfoundland (after Damman, 1983)

- I Western Newfoundland Ecoregion
 - Ia - Serpentine Range subregion
 - Ib - Corner Brook subregion
 - Ic - Port au Port subregion
 - Id - St. George's Bay subregion
 - Ie - Codroy subregion
 - If - Bay d'Espoir subregion
- II Central Newfoundland Ecoregion
 - Ila - Northcentral subregion
 - Ilb - Red Indian Lake subregion
 - Ilc - Portage Pond subregion
 - IId - Twillick Steady subregion
- III North Shore Ecoregion
- IV Northern Peninsula Forest Ecoregion
 - IVa - Coastal Plain subregion
 - IVb - Beaver Brook Limestone subregion
 - IVc - Northern Coastal subregion
 - IVd - Eastern Long Range subregion
- V Avalon Forest Ecoregion
- VI Maritime Barrens Ecoregion
 - VIa - Northeastern Barrens subregion
 - VIb - Southeastern Barrens subregion
 - VIc - South Coast Barrens subregion
 - VId - Central Barrens subregion
- VII Eastern Hyper-Oceanic Barrens Ecoregion
- VIII Long Range Barrens Ecoregion
 - VIIIa - Southern Long Range subregion
 - VIIIb - Buchans Plateau-Topsails subregion
 - VIIIc - Northern Long Range subregion
- IX Strait of Belle Isle Ecoregion



ECOREGIONS OF LABRADOR

1. Cape Chidley - Low Arctic Tundra
2. Torngat - Low Arctic Alpine
3. Kingurutik/Fraser - High Subarctic Tundra
4. Okak/Battle Harbour - Coastal Barrens
5. Michikamau - Mid-Subarctic Forest
6. Lake Melville - High Boreal Forest
7. Paradise River - Mid-Boreal Forest
8. Mecatina River - Low Subarctic Forest
9. Eagle River Plateau - String Bog
10. Forteau Barrens

Figure 6 - Ecoregions of Labrador (from W.J. Meades in S.J. Meades, 1990, Fig. A-20)

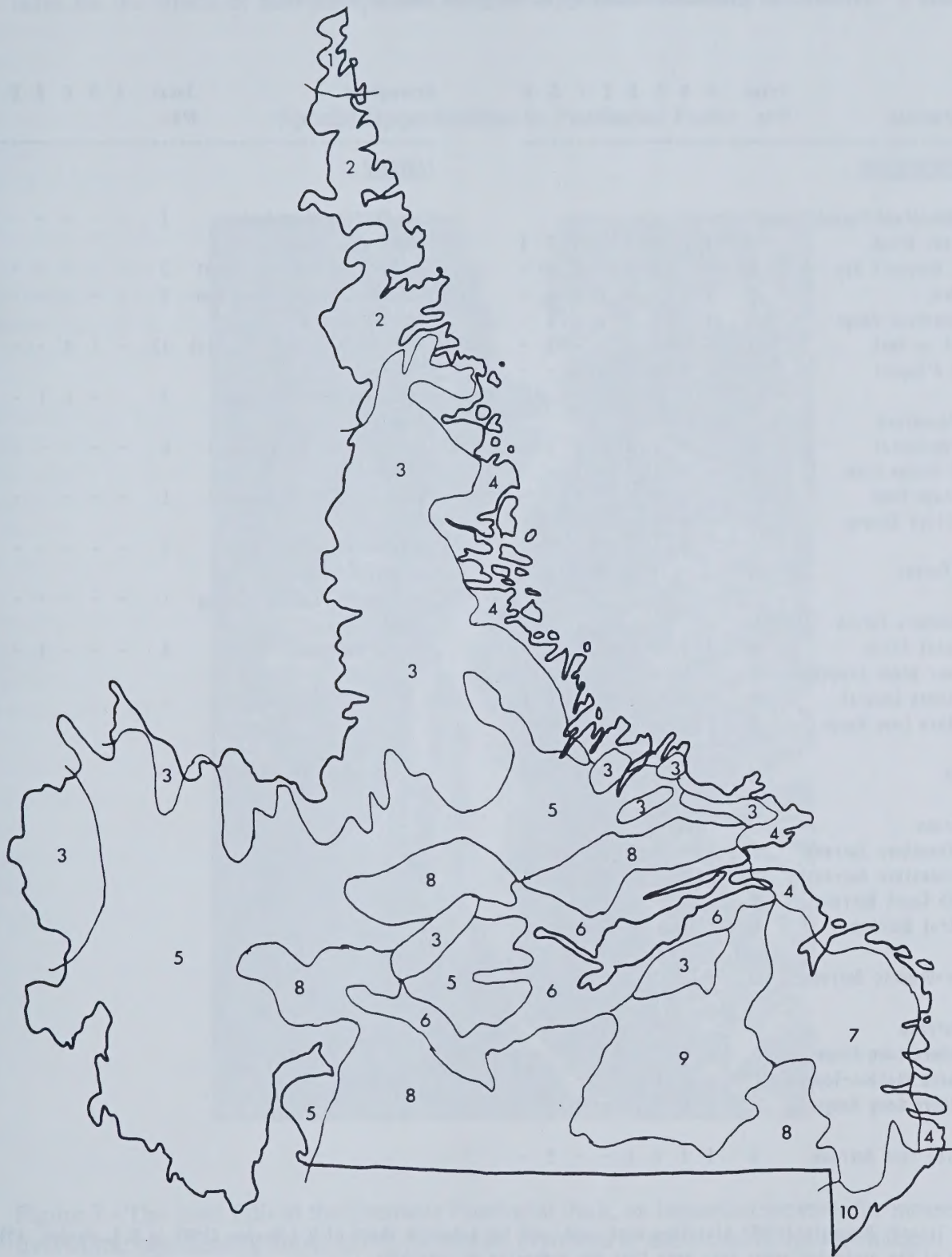


Table 5 - Number of protected areas by ecoregions and subregions.

Ecoregions Subregions	Total #PAs	A	B	C	D	E	F	G	H
<u>ISLAND OF NEWFOUNDLAND</u>									
Western Newfoundland Forest									
Corner Brook	9	1	-	2	2	-	1	2	1
St. George's Bay	6	-	-	2	1	-	2	1	-
Codroy	3	1	-	-	1	1	-	-	-
Serpentine Range	5	1	-	1	1	1	-	1	-
Port au Port	3	-	-	-	1	1	-	1	-
Bay d'Espoir	0	-	-	-	-	-	-	-	-
Central Newfoundland									
Northcentral	30	1	-	1	5	2	9	7	5
Red Indian Lake	2	-	-	1	-	-	1	-	-
Portage Pond	2	-	-	2	-	-	-	-	-
Twillick Steady	0	-	-	-	-	-	-	-	-
North Shore Forest	12	1	-	-	1	3	2	2	3
Northern Peninsula Forest									
Coastal Plain	8	2	1	2	1	2	-	-	-
Beaver Brook Limestone	0	-	-	-	-	-	-	-	-
Northern Coastal	3	-	1	-	-	-	-	1	1
Eastern Long Range	3	2	-	-	-	-	1	-	-
Avalon Forest	5	-	1	-	-	1	2	1	-
Maritime Barrens									
Northeastern Barrens	10	-	-	4	2	2	-	2	-
Southeastern Barrens	22	3	2	2	6	3	-	4	2
South Coast Barrens	9	1	1	-	3	-	-	3	1
Central Barrens	6	1	1	-	2	-	-	1	1
Eastern Hyper-Oceanic Barrens	16	-	4	2	3	5	-	2	-
Long Range Barrens									
Southern Long Range	0	-	-	-	-	-	-	-	-
Buchans Plateau-Topsails	1	-	-	1	-	-	-	-	-
Northern Long Range	1	1	-	-	-	-	-	-	-
Strait of Belle Isle Barrens	6	1	1	1	1	-	-	2	-

Ecoregions	Total #PAs	A	B	C	D	E	F	G	H
<u>LABRADOR</u>									
Cape Chidley (Low Arctic Tundra)	1	-	-	-	-	-	-	-	1
Torngat (Low Arctic Alpine)	3	-	-	-	-	-	-	-	3
Kingurutik/Fraser (High Sub-Arctic Tundra)	5	-	-	-	-	-	-	-	5
Okak/Battle Harbour (Coastal Barrens)	12	-	1	4	-	-	-	-	7
Michikamau (Mid Subarctic Forest)	7	-	-	1	1	-	-	-	5
Lake Melville (High Boreal Forest)	6	-	-	-	-	-	-	-	6
Paradise River (Mid Boreal Forest)	1	-	-	-	-	-	-	-	1
Mecatina River (Low Sub-arctic Forest)	2	-	-	-	-	-	-	-	2
Eagle River Plateau (String Bog)	1	-	-	-	-	-	-	-	1
Forteau Barrens	3	-	-	-	1	-	-	1	1

N.B. For the Island, Damman's (1983) divisions were used, and for Labrador those of W.J.Meades (1989 in S.J. Meades, 1990).
Some of the protected areas span more than one ecoregion or subregion.

A - National Parks, Historic Sites and Heritage Rivers
B - Wilderness Areas, Ecological Reserves, Nature Park
C - Provisional and Proposed Ecological Reserves
D - Natural Environment Parks

E - Natural and Scenic Attraction Parks
F - Outdoor Recreation Parks
G - IBP Sites not otherwise protected
H - Other PAs

lakes for the effects of acid precipitation, and the collection of weather data.

Special Opportunities in Provincial Parks

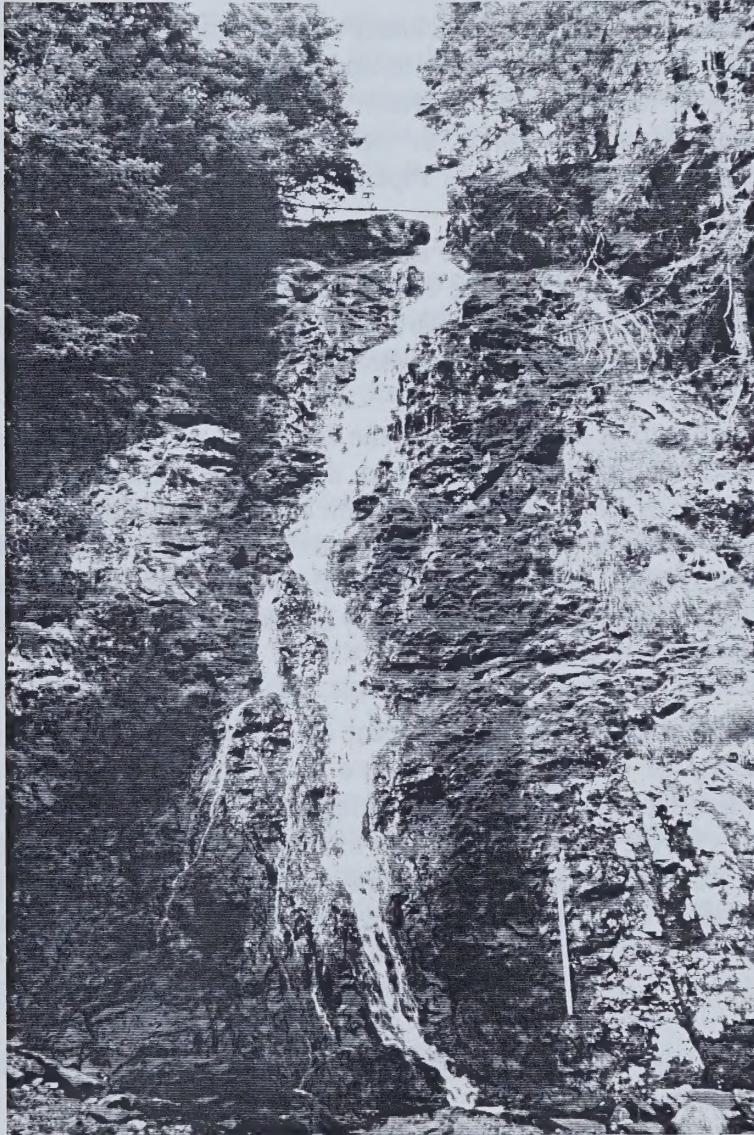


Figure 7 - The main falls at the Cataracts Provincial Park, an important location for mosses and liverworts, representing about 1/3 of the known bryoflora of the Island of Newfoundland. How will the diversity of flora here be affected by future climate change?

Among the 80 or so areas protected as provincial parks, many provide natural environments suitable for long-term monitoring and research. There are clean sandy beaches at Sandbanks, Deadman's Bay, Windmill Bight, Northern Bay Sands, Gooseberry Cove, and Bellevue Beach; lakes and ponds of special beauty such as at River of Ponds, Flatwater Pond, Notre Dame, Square Pond; magnificent tree stands as at David Smallwood and Barachois Pond (Figure 10); and delicate ecosystems such as the bryophyte community at Cataracts (Figure 7), and the sand bars and dune complexes at Point au Mal, Bellevue Beach, Codroy Valley, and Sandbanks again.

Some like Sandbanks, Cheeseman, Frenchman's Cove, and Chance Cove could form the basis for research on the interactions between landscape, plants and wildlife. In others there are opportunities to study the contrast between natural forest stands and adjacent plantations (Jipujikuei Kuespem, Barachois Pond), or the progressive recovery of natural versus planted forests after extensive fires (Catamaran, Pipers Hole, Butter Pot, Flatwater Pond).

At Black Bank the results of the erosive action of human feet (and ATVs) could be contrasted with the undisturbed steep slopes of the coastal embankment on either side of the park. There are the karst phenomena at Blue Ponds, the environmental effect of sand barriers built following the train wreck at Cheeseman, and the evolution and collapse of a natural blow-hole at Dungeon.

The extraordinary migration of the beach at the south end of Flatwater Pond, the fluctuation in the levels and biota of Holyrood Pond, and the natural variations in the lagoon outlet at Deadman's Bay are other dynamic situations which could be monitored to determine responses to climate change. Likewise, there are many possible ways to gauge the effects of regional change on the repeated stabilization and destabilization of beaches at Cheeseman, Codroy Valley, Point au Mal, Salmon Cove Sands, Northern Bay Sands, Sandbanks, Point La Haye, Gooseberry Cove, Bellevue Beach, and Windmill Bight.

At Blow Me Down and Barachois Pond, recent episodes of slope failure raise questions about causes and frequency of re-occurrence. There are many opportunities to study natural and human changes in landscape at Sandbanks, La Manche, Chance Cove, Cheeseman, Northern Bay Sands, Frenchman's Cove, and Dungeon. For example, one might investigate the way in which nature repairs the scars of former roads and railroads (Gushues Pond, Pipers Hole), sawmills (Dildo Run, Barachois Pond), and even telegraph lines (Jipujikuei Kuespem).

PROPOSED STRATEGY

Enhancing Environmental Monitoring and Research in Newfoundland and Labrador

There are no doubt many ways to increase environmental monitoring and research in Newfoundland and Labrador. Some current thinking on long-term monitoring links this to a few

intensive sites in which relatively detailed, multidisciplinary studies would be carried out where human disturbance is relatively low. These intensive sites would provide baseline references for comparison with more numerous **extensive** sites affected by localized stressors such as agricultural, forestry and industrial activities, and where fewer variables are monitored, but on a wider spatial scale to complete the regional picture (cf. Freedman et al., 1992). Results from intensive sites would also provide data for refining current indicators and for developing predictive models of ecosystem dynamics.

In Newfoundland, the two National Parks and some of the Historic Sites, Provincial Parks and Ecological Reserves could provide appropriate intensive sites, selected in part for their ability to represent different ecological regions. Comparison of these results and those obtained from monitoring extensive sites, both within and outside protected areas, should permit confident extrapolation of the data so as to give a comprehensive regional picture of environmental change.

Another approach would be to concentrate on various transects crossing important physiographic, climatic, or ecological boundaries such as that between the tundra and boreal forest biomes. Changes over time in many parameters could be monitored along a north-south transect from the tip of Labrador to southern Newfoundland. Examples include the position of the treeline and contours for the number of tree species (Figure 8A), moisture index (Figure 8B¹²), soil temperature, and peat de-gassing.

However since human and fiscal resources are unlikely to increase substantially in the near future, a pilot approach is suggested here. Based on the information recorded in the TERRAMON Database, one or more pilot areas would be selected in contrasted ecoregions and where substantial data sets already exist or are being gathered. Important ecological and other scientific issues would then be identified. Research projects and monitoring observations would be planned so as to fill the gaps in understanding of all relevant aspects of the natural environment.

Once an integrated research plan is available, opportunities to join a multi-disciplinary research team should be widely advertised, making full use of the TERRAMON network. Central funding would be ideal, but scientists and agencies attracted to such a "partnership" would also be expected to raise their own funds, for example through "A-Base" budgets or through the normal funding sources for scientific research. Integrated environmental research is certainly a priority area among some of the funding agencies today.

Results should be generated as effectively and swiftly as possible and results communicated

¹² Note that the various biophysical maps in the National Atlas of Canada series illustrate various key physical parameters, especially climatic and hydrological. Despite certain variations in methodology, they provide through the various editions of the Atlas - the current one is number 5 - a time-series of crude environmental "snapshots" of the evolution of the Canadian landmass.

widely, through scientific publications, conferences, workshops, videos, the media, and in any other way that publicizes, informs and educates the scientific community, the general public, and the policy and decision makers. These early demonstrations should be used to generate momentum (public interest, scientific participation, organizational support) for a larger program, which would extend to other areas to produce a continuous and integrated portrait of Newfoundland's natural environment.

A Pilot Area Approach

In addition to the obvious requirement for the existence of appropriate environments sensitive to climate, atmospheric and other changes (plant communities, aquatic systems, landscape elements, etc.) to monitor, there are several other factors that should be taken into consideration.

First, pilot projects should involve areas protected by the strongest legislation and regulations: Wilderness Areas and Ecological Reserves, Salmonier Wildlife Park, and the National Parks and Historic Sites.

Second, initial efforts should build on existing bodies of knowledge and expertise, i.e. where past studies have been carried out or where current observations are being made. National parks and provincial wilderness and ecological reserves are again the best candidates, especially those for which biophysical surveys or management plans exist.

Third, pilot projects should not be unduly hampered by a lack of access to key sites or the absence of other local infrastructure, both physical and administrative.

For every site chosen for long-term study the first task would be to establish present (baseline) conditions by means of a thorough biophysical survey¹³. Research and monitoring into the future would be done at appropriate intervals. Comparisons would be made, where possible, with adjacent areas more (or less) affected by human activities. Meteorological data would be required for virtually every study site: the presence nearby of an existing weather observation station would be a considerable asset. Wherever possible, past conditions would also be

¹³ The selection of key sites for study might draw on the experience of Bourdages and others (1992) in planning parks in the Montreal region. They make use of an "ecological evaluation approach" based on an "exhaustive knowledge of the biophysical environment." Each area is evaluated according to (1) uniqueness of its vegetation type, (2) representivity, (3) degree of succession and disturbance, (4) plant species richness, (5) presence of rare plant species, and (6) composition (richness and rarity) of bird communities.

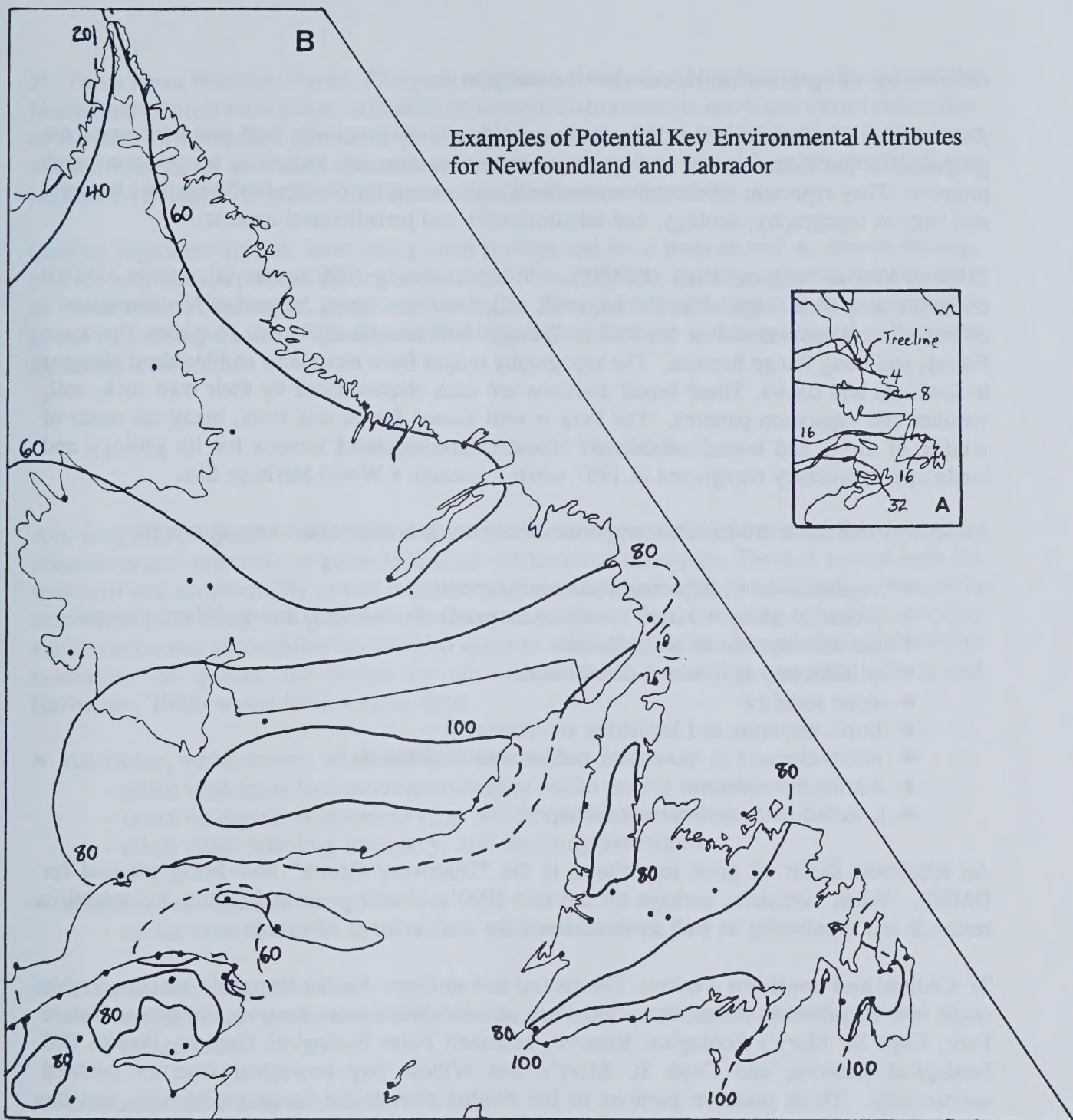


Figure 8A - Number of tree species (after Fig. 1 of Schueler, 1991).

Figure 8B - Moisture Index for Newfoundland and Labrador, based on a humidity index reflecting water surplus and an aridity index reflecting water deficiency. Dots indicate climatological stations. (From Map MCR 4096, 1990, "Climatic Regions. Thornthwaite Classification. Moisture Regions", National Atlas of Canada, 5th Edition).

determined, using historical records and natural proxies.

As examples of what might be done, three candidate areas involving well protected areas are proposed in the following. In each there are extensive data sets and many on-going research projects. They represent all ecoregions on the island, except for the Strait of Belle Isle Barrens, and vary in topography, ecology, and administrative and jurisdictional aspects.

1) Gros Morne National Park (GMNP): Within its nearly 2000 square kilometres, GMNP encompasses a wide range of landforms, rock, soil, and forest types. Several of Newfoundland's ecoregions are represented in the Park: Western Newfoundland Forest, Northern Peninsula Forest, and Long Range Barrens. The topography ranges from mountains and highland plateaus to lowlands and coasts. These broad divisions are each characterized by their own rock, soil, weather and vegetation patterns. The Park is well known for its rare flora, many the result of mixing of arctic and boreal conditions. Gros Morne is world famous for its geology and landscape, a diversity recognized in 1987 when it became a World Heritage Site.

In Gros Morne there are excellent opportunities to study and monitor, among others:

- vegetation in widely contrasted environments
- processes along a varied coastline, on peatlands and fens, and on inland plateaus
- the development of soil patterns
- wildlife populations and distributions
- slope stability
- fjord, estuarine and lacustrine environments
- micro-climates in mountains and on coastal lowlands.
- marine invertebrates
- a varied paleoenvironmental history

An additional factor of great importance is the "Discovery Centre" now being planned for GMNP. When complete, perhaps by the mid-1990's, it will provide facilities for scientific research and monitoring as well as a residence for a wide range of groups.

2) Central and Southern Avalon: The central and southern Avalon Peninsula contains a wide range of well-protected areas: Butter Pot Park, Avalon Wilderness Reserve, Salmonier Nature Park, Cape St. Mary's Ecological Reserve, Mistaken Point Ecological Reserve, Hawke Hill Ecological Reserve, and Cape St. Mary's and Witless Bay ecological reserves (seabird sanctuaries). These preserve portions of the Avalon Forest, the Maritime Barrens, and the Eastern Hyper-Oceanic Barrens.

Opportunities exist here to study rare plants, wildlife, forest, wetland and barrens vegetation, coastal erosion and deposition, patterned ground and a variety of micro-climates. Appropriate observations could be linked from one protected area to another to test networking across jurisdictional boundaries.

3) Terra Nova National Park: This park represents the Central Newfoundland Forest and the North Shore Forest ecoregions. Although its natural environment is much less varied than either of the other two proposed pilot areas, as the oldest national park or site in Newfoundland a large volume of data of relevance to environmental monitoring and research exists, especially as regards limnological (Kerekes, 1992), estuarine and botanical studies.

Current vegetation studies, involving ground surveys and fixed plots as well as remote sensing, provide an excellent point of departure for further work. There are also opportunities for work on small animals, estuaries, ponds and wetlands. Potential linkages could be established with future monitoring studies in the Bay du Nord Ecological Reserve and in provincial parks in the Bonavista Peninsula.

Setting Standards and Protocols

Any on-going program of scientific research and monitoring should have established criteria, procedures and protocols to guide individual workers and managers. There is a need both for standards and for flexibility so that monitoring programs, especially, can respond to changes in techniques and concepts. Agreements on the management of data, including collection, storage, manipulation and accessibility should also assist in enhancing the usefulness of data already in existence. In general the design for an environmental monitoring program (Davis and Halvorson, 1988) would have 5 basic steps:

- determine, what, where, when and how to monitor
 - select vital signs that measure ecological health and/or integrity
 - select ecological components (e.g. which species to monitor)
 - select sites, sampling frequency, and sampling techniques
- establish data management procedures
 - decide how to record, archive, and analyze raw data
- establish reporting procedures
 - define format (standards and guidelines for reports), audiences, and distribution of information
- document monitoring protocols
 - compile standardized handbooks that describe data, collection and analysis techniques in detail,
- implement and institutionalize monitoring
 - secure adequate personnel, support and long-term funding.

These steps have been followed in a well thought-out monitoring program in Channel Islands National Park, California (Davis and Halvorson, 1988), illustrated schematically in Figure 9. Most valuable are the ten monitoring protocol handbooks produced by the Park in 1988 for each of the following: pinnipeds, seabirds, rocky intertidal community, kelp forest (including marine invertebrates, marine vegetation and fishes), terrestrial vertebrates (including reptiles, amphibians, and mammals), land birds, terrestrial vegetation, fishery harvest, visitors, and weather. Additional handbooks were also planned on water and air quality, and terrestrial invertebrates.

ENVIRONMENTAL INDICATORS

The Question of Indicators

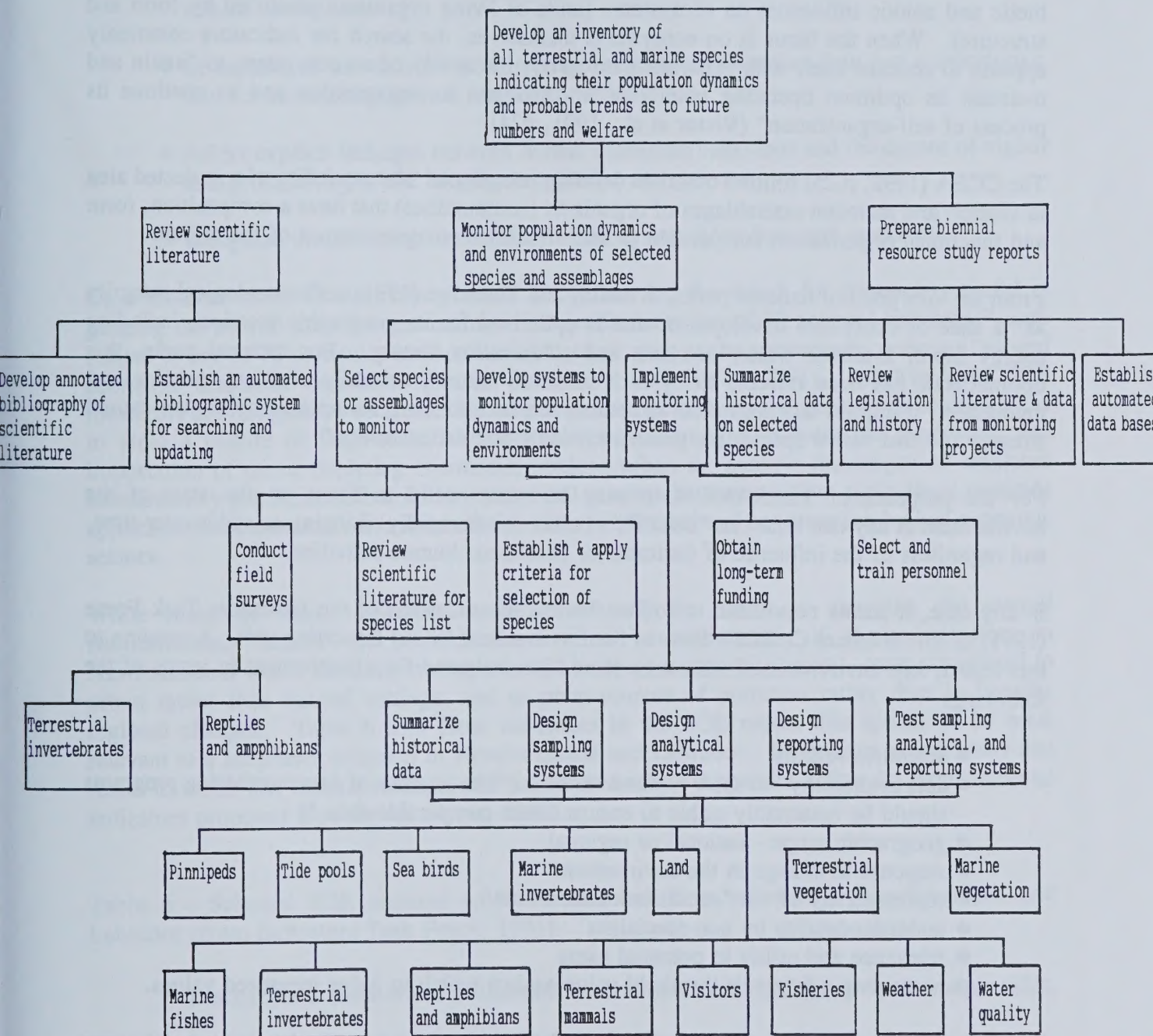
In order to assess the sustainability and integrity of the physical environment, indicators of environmental stability and change are required, especially those that can, like miners' canaries, warn of impending rapid change. As a physician assesses the health of a patient by monitoring her vital signs, so those responsible for judging the health of the natural environment need agreed protocols and standards. With concern increasing for the overall health of global, regional and local environments, the need for environmental indicators is becoming clearer. Norway and Canada are but two countries where concerted efforts are now being made to establish standard indicators, which can be aggregated to an index or profile.

Some useful definitions are given in a recent report from the Norwegian Ministry of the Environment (Anon, 1992):

- indicator* - "a parameter, or value derived from parameters, which points to/provides information about/describes the state of a phenomenon /environment/area with a significance extending beyond that obtained directly from the observed properties".
- index* - a "set of weighted parameters or indicators describing a condition of state".
- profile* - "coordination of a set of parameters, indicators or indices into a pattern which provides a visual and a readily comparable picture of a condition or state".

The subject of environmental indicators is a complex and intricate one, not least because the science of ecology is still relatively new. It is "premature to expect to be able to identify a universal set of indicators of integrity, and hence to have a formal quantitative methodology for evaluating ecological sustainability in all situations" (Victor et al., 1991, p.46). Moreover, determining a standard list of environmental indicators is immensely more difficult if they are

Figure 9 - Step-down plan for natural resources monitoring at Channel Islands National Park, California (Slightly modified from Davis and Halvorson, 1988, p15).



to be set against a background of concern for economic sustainability (Ruitenbeek, 1991). As the example of the Channel Islands National Park shows, the process is much simpler and more straightforward when the focus is on a specific ecosystem or landscape patch.

The stated aim of TERRAMON is to work on the whole "environment", including the external biotic and abiotic influences on ecosystems (units of living organisms identified by form and structure). When the focus is on ecosystems themselves, the search for indicators commonly appears to concern itself with **ecosystem integrity**, the ability of an ecosystem to "attain and maintain its optimum operating point", or to "maintain its organization and to continue its process of self-organization" (Victor et al., 1991, p24).

The CCEA (1992, p.25) follows others in defining integrity as "the capability of a protected area to support and maintain assemblages of organisms (communities) that have a composition, form and functional organization comparable to that of similar ecosystem types of the region.

From the viewpoint of national parks, Woodley and Theberge (1991) define ecological integrity as "a state of ecosystem development that is optimized for its geographic location, including energy input, available water, nutrients and colonization history. For national parks, this optimal state has been referred to by such terms as natural, naturally evolving, pristine and untouched. It implies that ecosystem structures and functions are unimpaired by human-caused stresses and that native species are present at viable population levels."

For the purposes of TERRAMON, it may be more useful to focus on the state of the environment at any one time - its "health", whether this is rapidly changing or stable over time, and regardless of the influence of desirable or pernicious human activities.

In any case, it seems reasonable to follow the recommendations of the Indicators Task Force (1991) of Environment Canada's State of the Environment (SOE) Reporting unit. According to this report, key environmental indicators should be evaluated for effectiveness in terms of the following:

- scientific validity
- data availability - to show trends over time ("The security of data monitoring programs should be reasonably stable to ensure future comparable data.")
- geographic scope - national or regional
- response to change in the environment
- representivity of the "condition of the whole"
- understandability by non-specialists
- relevance and utility to potential users
- possessing a target or threshold value against which to judge measured values.

It might also be advisable to go further and follow the Canadian Environmental Advisory Council in its "five new fundamentals" to be reflected in indicators of ecologically sustainable development (Ruitenbeek, 1991). According to CEAC, indicators should:

- reflect a **broader scope** - the economy and human behaviour within it should be acknowledged as a subset of the broader ecosystem which supports them;
- reflect **distributive elements** which are important from a social equity point of view costs and benefits of environmental degradation on various income and interest groups should be explicit;
- be capable of use as a forward-looking **projective tool** rather than just a descriptive tool for monitoring current or past conditions;
- reflect **explicit linkages** between human economic behaviour and the degree of vigour and productivity of the broader ecosystem; and
- recognize the **inherent uncertainty** in ecosystem behaviour and responses.

On a national level, Environment Canada (SOE) has led the search for parameters useful in gauging the overall Canadian environment. A preliminary list of 43 national indicators¹⁴ each related to one of 18 particular environmental "issues" such as the atmosphere, water or "natural economic resources" has been released (Indicators Task Force, 1991). Most of these SOE indicators are designed to be applicable over a wide range of time and geographic settings so as to yield a picture of large-scale, national changes. Examples include: the production and importation of ozone-depleting chemicals; outdoor urban air quality; discharges of regulated substances by petroleum refineries to water; rural to urban land conversion; agricultural pesticide application on cultivated land; and rates of water withdrawal and consumption by key economic sectors.

While many of these indicators could undoubtedly be useful in assessing the overall environmental "health" of Newfoundland - and measurements of these indicators in Newfoundland would certainly be important in building a national picture - most are related to urban rather than natural settings, and to point-sources of pollution rather than to broader regional changes. Table 6 lists those indicators in the SOE report that appear to be most relevant to a long-term program in Newfoundland and Labrador. Excluded are indicators that relate to urban and marine settings, and to human health. Appendix 3 lists the environmental indicators proposed for Norway (Anon, 1992).

Table 6 - Selected SOE national environmental indicators relevant to Newfoundland and Labrador (from Indicators Task Force, 1991).

- Discharges to fresh water and coastal waters from municipalities, pulp and paper mills,

¹⁴ In contrast the Norwegian approach considers that "about 20 indicators would probably be enough to describe the state of the environment in a country or region" (Anon, 1992).

petroleum refineries (BOD, TSS, P, oil and grease, ammonia, N, phenols, sulphide)

- Concentrations of N, P, pesticides in rivers
- Contaminant levels in Lake Trout and seabird eggs (PCBs, DDE, DDT, dioxins, furans)
- Wildlife species at risk
- Levels of migratory game bird populations
- Land under protected status
- Regeneration success versus total forest area harvested (eg. within PAs where controlled cutting is permitted)

Freedman and others (1992) assign possible indicators to **stressors** (e.g. pollutants, climate change, forest harvesting), **exposure** of ecosystems to stressors (the intensity of stress), and **response** of organisms and ecosystems to exposure to stressors (e.g. through mortality, change in productivity)¹⁵. On this basis they list various response indicators missing or under-represented from the SOE approach:

- habitat diversity
- changes in number, area and conservational adequacy of ecological reserves
- rare and endangered species and habitats (plants and invertebrates as well as mammals and birds)
- opportunistic species (ie. pests from the human perspective)
- species sensitive to change, (e.g. lichens)
- structural and functional indicators of response at the community level (e.g. changes in nutrient loss from watersheds).

A useful set of "measures of ecosystem integrity" is proposed by Woodley and Theberge (1992, p.375):

¹⁵ Though because "an indicator will always influence something and is usually at the same time influenced itself by something", it is "difficult to make a sharp distinction between stress indicators and response indicators" (Anon, 1992).

Individual scale	- growth and reproduction rates of indicator species
Population scale	- minimum viable population size - populations dynamics of selected species
Community scale	- species diversity - succession/retrogression - nutrient cycling
Landscape scale	- climate - primary productivity/respiration - minimum viable area - habitat fragmentation

As regards biodiversity, a new international program called Diversitas (see Appendix 2) provides helpful guidelines, even though its focus is not on the boreal realm. According to di Castri and others (1992), taxa to be monitored in the long term should represent:

- all major functional guilds: producers, herbivores, carnivores, parasites, mutualists, pathogens, saprobes;
- the full range of growth forms for vascular plants and fungi, and of body size and forms for animals;
- keystone species or representatives of keystone groups;
- a full range of geographic distribution characteristics, from narrow endemics to cosmopolitan species;
- representatives of species-rich and -poor groups, relatively abundant groups and relatively rare groups.

For tropical and temperate forests, the organizers of Diversitas recommend selecting the following life forms and taxa: trees - all taxa; selected dominant understorey plant taxa; fungi - lichens, mycorrhizas, etc; arthropods - spiders (selected families) and insects (10-15 selected families or subfamilies); vertebrates - amphibians, reptiles, mammals, birds (all taxa for each). Using the example of beetles, intensive study sites would monitor number of species, distribution of biomass, relative abundance, guild structure throughout the day and year, trophic structure, distribution in different forest levels (soil to canopy), ecological heterogeneity of the ecosystem. At extensive sites data would be gathered on number of species, distribution of individuals and of biomass, changes in numbers of species and in the ecological structures due to biogeographic

changes and ecological modifications.

Geological Indicators - Neglected Elements

The main body of thought on the subject of environmental monitoring has come from those concerned with ecosystem dynamics and integrity. This is natural given the well-known sensitivity to change of certain ecological vital signs such as population dynamics, biodiversity, energy flux, and nutrient budgets. Moreover, much of the public concern stems from fears that the well-being of wildlife, rare and endangered species (and spaces), and even human life itself, may be affected by environmental degradation.

Nevertheless, the physical environment also responds to natural processes in the soil, on the bedrock, and in the hydrosphere. These operate whether or not living organisms are present, though their rates and extents can be profoundly affected by biological agents, such as humans. Processes (melting, slumping, water table fluctuations) in the Arctic related to changes in permafrost depths and ultimately to atmospheric temperatures provide one example of this. Another is the range of dynamic processes (crustal rebound, glacial deposition, meltwater channelling) that shaped the land immediately¹⁶ after the recession of the last great ice sheets.

Landscapes today, especially those that are rocky or barren, are shaped and modified by physical processes such as soil movements, landsliding, coastal and river erosion and deposition, and frost-heaving). This is not to argue that these processes cannot be intensified or slowed by organisms, merely that they also operate in the absence of life. Any reasonably complete set of environmental indicators should therefore include those that describe surficial and near-surface earth processes¹⁷.

¹⁶ Some recent studies report major climate changes on a scale of a few decades at this time.

¹⁷ In recognition of this situation, the International Union of Geological Sciences created in mid-1992, through its Commission on Geoscience and Environmental Planning, a new Working Group on Environmental Geo-Indicators. The task of the WG is to compile an international checklist of geological indicators that will be useful for monitoring teams concerned with environmental changes on an annual or decadal scale.

Environmental Parameters to Monitor for Newfoundland and Labrador

An attempt at a comprehensive list of generalized monitoring parameters for Newfoundland and Labrador follows. This incorporates elements of the SOE indicator set and those listed by Freedman and others. Table 7 lists protected areas on the Island of Newfoundland where these are well exemplified. Various government agencies are already monitoring these and related parameters in one part of the province or another, as detailed in the TERRAMON Database. For many parameters it will be the rate and magnitude of change over time that is the most important to determine.

1) ATMOSPHERIC STUDIES

- Weather and microclimates: wind, precipitation, sunshine, fog, snow/ice melting in sensitive locations.
- Air and precipitation monitoring: Carbon dioxide, ozone, methane, and other key constituents, especially in relation to regional or point sources of release. Acid "Rain". Relation to changes in sensitive aquatic and other organisms.

2) BIOTA AND BIODIVERSITY

- Distribution, diversity, interrelationships, and other species and individual characteristics of plants, trees, birds, wildlife, insects, small land animals, coastal invertebrates, and soil organisms, especially from one habitat or ecoregion to another¹⁸. Priority on rare, less mobile and/or environmentally-sensitive species as regards:
 - contrasted ecoregions and ecosystems in forested areas, coastal barrens, uplands, coastal dune complexes:
 - areas where relatively undisturbed forests exist alongside those that have been recently

¹⁸ Note special opportunities in protected areas to monitor the natural "recovery" of areas formerly cleared, cut or otherwise disturbed by human action: roads, railroads, telegraph lines; ATV scars; villages, farms, homesteads, sawmills. These situations are important in that they involve situations where the time factor can be accurately determined, such as the date when a particular village was moved or railroad lines abandoned.

Table 7 - Special opportunities for environmental research and monitoring in national parks and historic sites, ecological and wilderness reserves, and provincial parks on the island of Newfoundland.

Protected Area	Feature* to Monitor (see list below. 0 - Priority Areas)																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Arches	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
Aspen Brook	.	.	.	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Avalon Wilderness	.	0	.	.	.	0	.	0	.	X	0	.	X	X	.	0	0	0	.	.	X	.
Baccalieu Island	.	.	X	.	.	.	.	.	.	0	.	.	.	X	.	.	.	.	.	.	.	.
Backside Pond	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	X	.
Barachois Pond	.	X	.	X	.	X	0	X	X	0	.	.	X	.	0	0	.	X	0	X	.	.
Bay du Nord	.	X	.	0	.	.	.	0	.	X	.	.	0	X	.	X	.	0	0	X	.	.
Bellevue Beach	.	.	.	.	.	.	.	.	.	.	.	.	.	0	.	.	.	.	.	.	X	.
Black Bank	.	.	.	.	.	.	.	.	.	.	.	.	.	0	.	.	.	.	.	.	.	.
Blow Me Down	.	.	.	X	.	.	.	.	X	.	.	.	.	X	.	0	.	.	.	.	.	.
Blue Ponds	.	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.	.	.	.	0	.	.
Bottle Cove	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
Butter Pot	.	.	.	X	.	.	.	X	X	.	.	.	.	.	.	.	X	X	.	X	.	.
Cape St. Mary's	.	.	X	.	.	.	.	.	X	0	.	.	.	0	.	.	0	X	.	.	.	.
Castle Hill	.	.	.	.	.	.	.	.	.	.	.	.	0	.	.	.	.	.	.	.	.	.
Catamaran	.	.	.	.	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cataracts	.	.	.	.	.	.	X	0	.	.	.	.	.	.	0	.	.	.	.	.	.	.
Chance Cove	.	.	.	.	.	.	.	.	0	.	X	.	X	X	X	.	0	.	.	.	X	.
Cheeseman	.	.	X	.	X	.	.	X	X	.	.	X	.	0	.	.	.	X	X	.	X	.
Codroy Valley	.	.	.	0	.	.	.	.	.	.	.	.	.	0	.	.	.	.	.	.	.	.
David Smallwood	.	X	.	.	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.	.	.
Deadman's Bay	.	.	.	0	.	.	.	X	.	X	.	.	.	0	.	.	.	.	.	0	.	.
Dildo Run	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.
Dungeon	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.
Eastport North	.	.	.	.	.	.	.	.	.	.	.	.	.	0	.	.	.	.	.	.	.	.
Fitzgeralds Pond	.	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.
Flatwater Pond	.	.	.	.	.	.	.	.	.	.	.	.	X	.	0	.	.	.	.	.	.	.
Fortune Head	.	.	X	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.	.	.	.
Frenchmans Cove	.	X	.	.	.	.	X	.	0	.	.	.	X	.	0	.	.	.	.	X	.	.
Freshwater Pond	.	X	.	.	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.	.	.
Funk Island	.	.	.	.	.	.	.	.	0	.	.	.	.	.	.	.	.	.	.	.	.	.
Grand Codroy	.	.	.	.	.	.	X	.	0	.	.	.	X	.	X	.	.	.	.	X	.	.
Gooseberry Cove	.	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
Gros Morne	.	0	0	0	0	0	0	0	0	0	0	X	0	0	0	0	0	0	X	0	0	0
Gushues Pond	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.
Hare Bay	.	.	.	.	.	.	X	.	0	.	.	.	.	.	.	.	.	.	.	.	.	.
Hawke Hill	.	.	0	.	.	.	0	.	.	.	.	X	.	.	.	0	.	.	.	.	.	.
Holyrood Pond	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	X	.	.
Indian River	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X
Jacks Pond	.	.	.	.	.	.	.	.	.	.	X	X	X	X	.	.	.	.	.	.	.	.
Jiggin Head	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.
Jipujikuei Kuespen	.	.	.	.	0	.	.	X	.	.	X	.	.	.	.	.	.	.	.	X	.	.
King George IV Lake	.	.	.	.	.	.	.	0	.	0	.	.	.	.	X	.	.	.	.	X	.	.
La Manche	.	.	.	.	.	.	.	.	.	.	0	.	0	X	0	.	.	.	.	.	.	.
L'Anse aux Meadows	X	0	.	.	.	.	.	.	X	.	.	.	.	X	.	.	X	0	0	.	.	.

Protected Area	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
Main River	.	X	.	.	.	0	X	X	0	.	.	.	.	.	X	.	.	.	.	.	.	.	.
Marine Drive	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	X	.	.
Mistaken Point	.	.	X	.	.	.	.	.	.	.	X	.	X	0	.	.	0	X	.	.	.	.	.
Mummichog	.	.	.	.	.	.	X	0	.	.	.	.	X	.	X	.	.	.	.	.	X	.	.
Northern Bay Sands	.	.	.	.	.	.	.	.	.	.	.	.	X	X	X	.	.	.	.	.	.	.	.
Notre Dame	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.
Pipers Hole	.	.	.	.	0	.	X	.	X	.	X	.	.	.	0	X	.	0	.	.	.	.	.
Pistolet Bay	.	X	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.
Point au Mal	.	.	.	X	.	.	.	.	.	.	.	.	.	0	.	.	.	X	.	.	.	.	.
Point La Haye	.	.	.	.	.	.	.	.	.	.	X	.	0	.	.	.	.	.	.	.	.	.	.
Port au Choix	.	.	0	.	.	.	.	0	.	.	.	X	0	X	.	.	0	0	.	X	.	.	.
Salmon Cove Sands	.	.	.	X	.	.	.	.	.	.	.	.	.	0	.	.	.	.	.	.	X	.	.
Salmonier	.	X	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.	X	.	.	.	.	.
Sandbank	.	.	.	0	.	.	.	.	.	X	.	.	X	0	0	.	.	X	.	.	.	.	.
Sepoy Hill	.	.	.	.	.	.	0	.	X	.	.	.	.	X	X	X	.	.	.	.	X	.	.
Signal Hill	.	.	X	.	.	.	.	.	.	.	X	.	0	X	.	.	.	.	.	X	.	.	.
Sops Arm	.	.	.	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
Squires	.	.	.	.	.	.	X	.	.	.	X	.	.	.	0	.	.	.	.	.	.	X	.
Stag Lake	.	X	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.
Table Point	.	.	0	.	.	.	.	0	.	.	X	.	.	X	.	.	0	.	.	.	.	.	.
Terra Nova	.	0	.	.	.	X	.	0	X	0	0	0	.	0	0	.	0	0	.	0	.	0	.
Watts Point	.	.	0	.	.	.	.	0	0	.	.	.	.	X	.	.	0	X	X	.	.	.	.
West Brook	.	X	.	.	.	.	.	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Windmill Bight	.	.	X	.	0	.	.	X	.	X	.	.	X	.	0	.	.	0	.	.	X	.	.
Witless Bay	.	.	.	.	.	.	.	0	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.

FEATURES TO MONITOR

BIOTA AND BIODIVERSITY

Contrasted ecoregions & ecosystems:

- 1) Forest
- 2) Coastal barrens
- 3) Uplands
- 4) Coastal sand dunes
- 5) Burned, or adjacent to harvested or replanted forests
- 6) Old-growth stands
- 7) Lakes, rivers, estuaries
- 8) Rare and endangered animal and plant species and those in special niches
- 9) Ecotone dynamics at treelines
- 10) Bird studies

Recovery from Human Disturbance:

- 11) Roads, RRs, telegraph lines
- 12) ATV scars
- 13) Villages, farms, fortifications, homesteads, sawmills

LANDSCAPE DYNAMICS

- 14) Coastal erosion/deposition
- 15) Erosion/deposition along rivers and lakes
- 16) Hillslope instability

SOILS

- 17) Soil dynamics
- 18) Development of peatlands
- 19) Soil temperatures

WATER

- 20) Lakes and ponds
- 21) Intertidal lagoons/marshes
- 22) Groundwater quality

burned or replanted:

- forest productivity in cutting areas, community structure, fire history, succession, pest and disease incidence. Old-growth stands,
- aquatic ecology of lakes, rivers, estuaries (algae, insects, etc.):
- rare and endangered plant, animal and bird species, both within and between the larger PAs such as Bay du Nord, Gros Morne, Torngat Mountains. Including special estuarine and inland water fish such as mummichog, and insects in special niches, such as chironomids.
- land vertebrates such as meadow voles which are close to the base of the food chain.
- species near the limits of their distribution, and those known to be sensitive to environmental change such as lichens (effective bio-monitors of SO₂, ozone, heavy metals and toxic chemicals), and bryophytes. Also contaminant levels in birds eggs and fish in inland waters.
- migration, nesting, feeding and breeding patterns of seabirds (valuable indicators of fish populations), raptors and waterfowl¹⁹.
- stability of boundaries between distinct vegetation communities, for example at treelines. Animal and plant distribution and diversity across ecotones.

3) LAND USE

- Processes of conversion of land once used (e.g. farmland, village, or tree-cutting area) to wilderness as new areas are protected, with clear implications for ecosystem dynamics²⁰.
- Changes in the degree of protection (laws, regulations, management) of individual PAs and in the proportion of land set aside as PAs, especially in Labrador. Fragmenting of wildlife habitat as a result of developments outside PAs.

¹⁹ Note that many of the key sites are already protected in one form or another.

²⁰ The value of such situations is that the change in land use can be determined and a time-line established against which to calculate rates of "recovery".

4) LANDSCAPE DYNAMICS

- Coastal erosion/deposition: erosion rates on cliffs and coastal embankments (especially those composed of unconsolidated material), blow-outs in coastal dunes, and movement of beaches; movement of individual boulders on beaches and fore-shores in response to changing coastal conditions. Link to studies of coastal morphology, sea levels, tides, wave action, stabilization by vegetation (natural and planted), and de-stabilization by human action.
- Erosion/deposition along rivers, lakes and estuaries: discharge rates and movement of sediment; accumulation of clastic and organic sediments.
- Hillslope stability: rates of recent landslides, rockfalls, and debris flows in hilly areas, both coastal and inland. Relationship to precipitation, run-off, frost action, tree-cutting.
- Tidal forces and sea-level change: fluctuation of low and high tide levels relative to a fixed datum, variations in past sea levels.

5) SOILS²¹

- Soil creep and movement by repeated frost action leading to development of patterned ground. Changes in chemical, biological and physical composition: depth to parent material or root-restricting layer, texture, colour, structure, slope and drainage class, root and biopore distribution; soil temperature.²²

²¹ Despite the vast amount of research available on the environmental setting of different soils types, relatively little use appears to have been made of soil characteristics and processes as environmental indicators. To stress their importance, the IGBP has identified data on soils, which "appear to be the most elusive", as essential for its core research projects. Agriculture Canada has recently begun to develop a comprehensive national program to monitor agricultural soil quality. A small number of benchmark sites are being established where long-term soil monitoring will be carried out - one has recently been set up at the Brookfield Research Station near St. John's.

²² As regards soil temperature, recent techniques developed largely for Arctic and sub-Arctic soils have demonstrated how temperature depth profiles can yield valuable information about past surface temperatures. If the occurrence of palsas on bogs and fens in northern Newfoundland reflects the presence of soils that have recently been frozen year-round, what can they tell us about the temperature variations of the recent past? And if soils respond rapidly to climate changes, then monitoring ground temperatures at fixed sites, especially in Labrador and

6) WATER

- Lakes and ponds: chemistry, sedimentation, precipitation, biota, temperature profiles. Link to all watershed processes.
- Intertidal lagoons/marshes: sedimentation, tidal ranges, biodiversity.
- groundwater quality: Chemistry/potability of well water
- stream flow and basin drainage

7) WETLANDS

- Fens, swamps, marshes and peatlands²³ - rate of lateral and vertical growth or decline. Methane generation, carbon mass balance, fluctuations in hydrological conditions.

LINKAGES AND SPIN-OFFS

Potential Links with Other Programs

An extensive list of organizations and programs working in the province or in relevant areas elsewhere is given in Appendix 2. Many of the programs now operating in the province by government agencies are open for expansion and outside cooperation, depending on resources available. There are also many existing or planned national and international programs on global change and/or ecosystem research, with which any program on environmental change in Newfoundland and Labrador could usefully establish linkages, even though not all are now working in Atlantic Canada. In some cases there are opportunities for direct participation, on

northern Newfoundland may prove useful as a gauge of one important response to future climate change.

²³ For peatlands, the vertical and lateral rates of accumulation would seem to be obvious parameters to monitor, especially since it is here that studies of pollen profiles can provide estimates of rates of growth or decline over much of the past 10,000 years of post-glacial history.

others a watching brief should be maintained so as to take advantage of new technical and scientific advances and experiences.

Most of the research programs have linkages with or are being watched by the **Canadian Global Change Program (CGCP)**. Operating from the Royal Society of Canada, this is the Canadian base of the **International Geosphere-Biosphere Programme**²⁴ and is probably the best single "window" into global change research elsewhere.

Economic and Other Benefits of Long-term Monitoring

Of greatest value in the long-term will be the enhanced understanding of the environment and the distribution, quality and quantity of the fish, forest, agricultural, water, soil, land and wildlife resources of the province. The more we know and understand about the natural and human processes that shape our land and its resources, the better we will be able to develop and manage them for the common good. Better monitoring of forests, fish population, air and water quality, weather, moose and caribou, coastal erosion, and tides will provide local, regional and provincial authorities with the scientific and technical background they need to optimize resource development and usage. An enhanced ability to forecast environmental changes will have beneficial effects not only on the living and non-living resources (forests, plants, animals, birds, lakes and streams, fish), but also on programs and facilities for visitors and tourists.

In the short-term, an on-going monitoring program should lead directly to

- employment, mainly seasonal and part-time, of local residents and others involved in field surveys and data collection²⁵;
- employment for few full-time workers as expeditors, transporters and field assistants to principle scientific investigators;

²⁴ A former IGBP proposal for "geosphere-biosphere observatories" was an early catalyst for the TERRAMON concept.

²⁵ A ready source of local field assistants may be available through the newly-created Conservation Corps. Volunteers may also be obtained through EarthWatch, the well-known US-based organization.



Figure 10 - Eastern White Pine at Barachois Pond Provincial Park. What information about the climate of the past 200-300 years be extracted from a study of tree rings of these old trees? Can they and the stands of old White Pine upstream along Little Barachois Brook be used as a genetic reserve?

- an increase in the availability of the scientific and technical information required by managers of parks and protected areas to fulfil their mandates of environmental conservation and protection; and
- new opportunities for training courses and field institutes for environmental scientists and managers from other countries who could benefit from the experience in Newfoundland and Labrador in integrated environmental research and monitoring.

Among the **indirect benefits and spin-offs** to be expected are

- increased use of local facilities (housing, catering, transportation, stores) by scientists, graduate students and their field assistants while doing field work;
- increased opportunities for production of educational materials (booklets, videotapes, calendars) explaining environmental monitoring work;
- increased use of provincial expertise in ecology, wildlife, geology, hydrology, soils, forestry, remote sensing, information and data handling, etc.; and
- new ideas and opportunities for ecotourism/adventure tours linked to greater awareness of Newfoundland ecosystems.²⁶

An integrated program of long-term research and monitoring would also provide opportunities for increased scientific activities and public awareness of the importance of Newfoundland's parks and protected areas, thus strengthening the case for their own protection. As stated earlier, many of these contain ecosystems of considerable interest, but few are now being utilized other than for public recreation and enjoyment.

TERRAMON has already initiated new forms of cooperation and joint activities with governmental departments (forestry, wildlife, parks). This could be extended to non-governmental organizations (eg. Atlantic Centre for the Environment, PAA), regional development associations, municipal and town councils.

Finally, TERRAMON should raise the **environmental profile** of Newfoundland and Labrador, and may provide a model for other environmental programs in other areas. No other province in Canada appears to be developing a similar approach to regional monitoring. Newfoundland thus has a chance to play a pioneering role in the increasingly important endeavour of safeguarding and improving the natural environment. There could be many opportunities for conferences, study and field seminars and excursions, symposia, and other forms of advanced communication, even for "twinning" with areas and programs in similar environments elsewhere. This means more visitors to Newfoundland and more work for provincial firms and experts.

²⁶ It is estimated that 25% of world trade is now related to tourism, of which 10% may be classed as "adventure tourism." According to a 1981 survey quoted by Keddy (1989) 19% of Canadians participated in trips or outing specifically to encounter wildlife, excluding hunting trips. The September 1991 issue of National Geographic (p134) referred to a 1980 US survey which showed that 93 million people watched wildlife for recreation. In 1985 a second survey showed 135 million people, who spent \$14 billion in the watching.

CHALLENGES TO TERRAMON

The setting up of TERRAMON has created an opportunity now to establish an integrated, province-wide system of environmental research and long-term monitoring. This would link with, enhance and expand existing sectoral monitoring programs now being carried out by provincial and federal agencies. TERRAMON could lead the way on a national level as a cooperative network of bilateral and multilateral partnerships, and provide a functioning model for other regions. Economic spin-offs could be significant.

For this to occur, however, a thorough science plan is needed. This would fill existing gaps in environmental work and would be revised from time to time as new research questions and issues are raised and new scientific models and techniques developed. Critical sites must be identified, and decisions must be made on key parameters (indicators) and appropriate standards and protocols for research and monitoring. Finding the scientific expertise needed will not be easy, but it should be possible to attract good personnel from outside the province by the prospect of participation in a truly cross-disciplinary program related in practical terms to global change²⁷ and fundamental to achieving environmental sustainability.

A system for managing data and archiving samples for future use and reference is essential. This requires constant updating of central data banks, and periodic tests of their relevance and usefulness. Frequent outputs of the scientific data and results will need to be prepared in a form that is understandable to planners and decision-makers, provincially and nationally.

However, the greatest challenge will undoubtedly be to secure the funding to launch and continue a long-term program. The national Green Plan recognizes the need for environmental research and monitoring, and several federal departments have designed new funding "windows", such as the Model Forest Program. The initial need will be to find the core and operational funds required to plan the system and launch pilot projects. Once these phases are under way, it should be possible for much of the research to be done by the scientific community with funds from the normal sources (e.g. NSERC, MRC). Likewise, it should be possible to incorporate much of the long-term monitoring required into regular "A-Base" or line items in government budgets.

If Newfoundland and Labrador can plan, find support for and launch such a program, the result can only be of benefit to the province, in direct and indirect economic terms. The prospect of a national and international environmental "profile" is only made more challenging by the

²⁷ providing, for example, the "ground truthing" required to calibrate regional and global models of climate change.

present environmental crisis in the fishery, upon whose formerly "unlimited" wealth Newfoundland was originally settled and a distinct, now Canadian, culture was founded.

REFERENCES

- Anon, 1974. Report of Region 8 (Newfoundland and Labrador). Unpublished report to International Biological Programme, Conservation of Terrestrial Communities, 37p.
- Anon, 1988. Provincial Park Policy and Park Classification and Zoning System. Parks Division, Government of Newfoundland and Labrador, 71p.
- Anon, 1991. Canadian Parks Service Proposed Policy. Environment Canada Parks Service, 117p.
- Anon, 1992. Proposal for Environmental Indicators in Norway. Report 1 of the Reference Group for Environmental Indicators, Ministry of the Environment, 25 June, 1992.
- Beechey, T.J., 1989. Guidelines for the selection of protected ecological areas. Canadian Council on Ecological Areas, Occasional Paper 5, 14p.
- Berger, A.R., 1991. TERRAMON - Towards a role for Newfoundland's protected areas in integrated environmental monitoring. Unpublished report to Protected Areas Association, St. John's, 30p.
- Berger, A.R., 1992. A special role for parks and protected areas in long-term environmental monitoring. In J.H.M. Willison et. al (eds), Science and the Management of Protected Areas, Elsevier, p 385-390.
- Bourdages, J.-l., Domon, G., Draspeau, P. and Bouchard, A., 1992. Land-use planning of protected areas: an approach based on the ecological value. In J.H.M. Willison et. al (eds), Science and the Management of Protected Areas, Elsevier, p 95-105.
- CCEA, 1992. Canadian Council on Ecological Areas framework for developing a nation-wide system of ecological areas. Part 1 - a strategy. CCEA Occasional paper, July 1992, 39p.
- Comanor, P.L. and Dennis, J.G., 1992. U.S. National Parks: benchmarks contributors to long-term global change research. In J.H.M. Willison et. al (eds), Science and the Management of Protected Areas, Elsevier, p 379-384.
- Damman, A.W.H., 1983. An ecological subdivision of the Island of Newfoundland. In G.R. South (ed) Biogeography and ecology of the Island of Newfoundland. W. Junk Publishers, The Hague.

- Davis, G.E. and Halvorson, W.L., 1988. Inventory and monitoring of natural resources in Channel Islands National Park, California. National Park Service, U.S. Dept of the Interior, Channel Islands National Park, 31p.
- di Castri, F. and Hadley, M., 1992. Interdisciplinarity and environment and the flaming moth principle. *Biology International*, No. 25, p. 17-21.
- di Castri, F., Robertson Vernhes, J. and Younes, T., 1992. Inventorying and monitoring biodiversity: a proposal for an international network. *Biology International*, Special Issue 27, 28p.
- Eidsvik, H.K., 1992. Strengthening protected areas through philosophy, science and management: a global perspective. *In* J.H.M. Willison et. al (eds), *Science and the Management of Protected Areas*, Elsevier, p9-18.
- Freedman, B., Shackell, N.L., and Staicer C.A. 1992. A Framework for a National Environmental Monitoring Program. Unpublished report to SOE, January 1992, 18p.
- IGBP, 1990. IGBP: A Study of Global Change - The Initial Core Projects. IGBP Report 12, not paginated throughout.
- Indicators Task Force, 1991. A Report on Canada's Progress Towards a National Set of Environmental Indicators. State of the Environment Reporting, Environment Canada, SOE Report 91-1, 98p
- IPCC, 1990. Scientific Assessment of Climate Change. Report Prepared for the Intergovernmental Panel on Climate Change by Working Group 1 (J.T. Houghton, Chairman), WMO and UNEP, 365p.
- Keddy, P.A., 1989. Sustainable development, scientific research and ecological areas. Canadian Council on Ecological Areas Occasional Paper 4, 15p.
- Kerekes, J.J., 1992. Aquatic research and long term monitoring in Atlantic Canada's national parks. *In* J.H.M. Willison et. al (eds), *Science and the Management of Protected Areas*, Elsevier, p. 411-16.
- Lopoukhine, N., Prout, N.A., and Hirvonen, H.E., 1978. The ecological land classification of Labrador: a reconnaissance. *Ecological Land Classification Series 4*, Lands Directorate, Environment Canada, 85p.

- Meades, W.J. and Moores, L. 1989. Forest Site Classification Manual. A Field Guide to the Damman Forest Types of Newfoundland. Forestry Canada and Newfoundland Department of Forestry and Agriculture, FRDA Report 003, not paginated throughout.
- Meades, S. J., 1990. Natural Regions of Newfoundland and Labrador. Unpublished report to Protected Areas Association, 475p.
- Mooney, H.A., Medina, E., Schindler, D.W. Schulze, E.-D. and Walker, B.H. (eds), 1991. Ecosystem Experiments - SCOPE 45. John Wiley and Sons, 268p.
- Peterson, E.B. and Peterson, N.M., 1991. A first approximation of principles and criteria to make Canada's protected area systems representative of the nation's ecological diversity. Canadian Council of Ecological Areas, Occasional Paper, 62p.
- Risser, P.G. (ed.), 1991. Long-Term Ecological Research: an International Perspective - SCOPE 47. John Wiley and Sons, 294p.
- Ruitenbeek, H.J., 1991. Indicators of Ecologically Sustainable Development: Towards New Fundamentals. Canadian Environmental Advisory Council, 34p.
- Schueler, F.W. and McAllister, D.E., 1991. Maps of the number of tree species in Canada: A pilot GIS study of tree biodiversity. Part 1. Canadian Biodiversity, vol.1, no. 1, p. 22-29.
- Taylor, C., Lambert, E., and Freundsuh, S., 1991. A geographical information systems approach to protected areas planning for the Island of Newfoundland. Unpublished report to Protected Areas Association, 54p.
- Turner, A.M., Rubec, C.D.A., and Wiken, E.B., 1992. Canadian ecosystems: a systems approach to their conservation. In J.H.M. Willison et. al (eds), Science and the Management of Protected Areas, Elsevier, p. 117-127.
- Victor, P.A., Kay, J.J., and Ruitenbeek, H.J., 1991. Economic, Ecological, and Decision Theories: Indicators of Ecologically Sustainable Development. Canadian Environmental Advisory Council, Ottawa, 90p.
- Wiken, E., 1986. Terrestrial ecozones of Canada. Ecological Land Classification Series, No. 19, Lands Directorate, Environment Canada, 26p.

Wiken, E.B., Rubec, C.D.A., and Ironside, G.R., 1987. Terrestrial Ecoregions of Canada - Provisional Map (1:7,500,000). Environment Canada, Inland Waters/Lands.

Woodley, S. and Theberge, J., 1992. Monitoring for ecosystem integrity in Canadian National Parks. In J.H.M. Willison et. al (eds), Science and the Management of Protected Areas, Elsevier, p. 369-78.

APPENDICES

APPENDIX 1 - ENVIRONMENTAL DATASETS FOR NEWFOUNDLAND AND LABRADOR

(Names in CAPS indicate formal databases; those in lower case are less formal data sets)

DATA SET NAME	DATA SET LOCATION
ACID RAIN (WET DEPOSITION AND AEROSOL SULPHATE MONITORING NETWORK)	Environment Canada
AGC - GEOCHEMISTRY DATABASE	Atlantic Geoscience Centre
AGC - MULTIPARAMETER DATABASE	Atlantic Geoscience Centre
AGC - OFFSHORE SURFICIAL GEOLOGY MAP SERIES	Atlantic Geoscience Centre
AGC - ONSHORE WELL DATA (OSWELL)	Atlantic Geoscience Centre
AGC - QUATERNARY BIOSTRATIGRAPHY (BUGS)	Atlantic Geoscience Centre
AGC - SAMPLE ANALYSIS DATA BASE (SAD)	Atlantic Geoscience Centre
AGC - WELL INFORMATION DATABASE	Atlantic Geoscience Centre
AGC/ESRF EAST COAST ICE SCOUR DATABASE	Atlantic Geoscience Centre
ANNUAL CENSUS OF NEWFOUNDLAND MINES & ENERGY - QUARRIES AND SANDPITS	Geological Survey Branch
AQUASITE	Dalhousie University
ATLANTIC CANADA WATER QUALITY MONITORING PROGRAM FOR MUSSEL GROWERS	Acadia University
ATLMON (Atlantic Monitoring Data)	Environmental Protection, EC
BIRD BANDING AND RECOVERY DATABASE	Canadian Wildlife Service

BREEDING BIRD SURVEY	Canadian Wildlife Service
CANADA FOREST RESOURCE DATA SYSTEM	Canadian Forestry Service
CANADIAN AIR AND PRECIPITATION MONITORING NETWORK - CAPMoN	Atmospheric Environment Service
CANADIAN BIODIVERSITY DATABANK (BIODIV)	Canadian Museum of Nature
CANADIAN GEOSCIENCE DATA DIRECTORY	Geological Survey of Canada
CLOSED OR ABANDONED LAND DISPOSAL SITES	Inland Waters Directorate
COASTAL Geomorphology and Sediments of Newfoundland	Atlantic Geoscience Centre
COASTAL INFORMATION SYSTEM	Atlantic Geoscience Centre
Coastal Landforms and Ecosystems of Northeast Newfoundland	Lands and Integrated Programs Directorate
Coastal Sensitivity of Southwest Newfoundland	Environmental Protection, EC
Coastal Zone Landforms and Ecology of Southeast Newfoundland	Lands and Integrated Programs Directorate
COMPENDIUM - COMP	Environmental Protection, EC
CONTAMINANT BORDERS AND TRANSFERS FROM MOTHER TO YOUNG IN WHALES & SEALS	DFO
CONTAMINANTS IN HARBOUR SEDIMENTS	Land and Sea Consultants
Cooperative Holocene Mapping Project (COHMAP)	Brown University
CREEL CENSUSES - NATIONAL PARKS	Canadian Parks Service
DIGITAL ARCHIVES OF CANADIAN CLIMATOLOGICAL DATA	Atmospheric Environment Service
DISEASES IN FRESHWATER FISH IN	DFO

NEWFOUNDLAND AND LABRADOR

DISTRIBUTION OF THREATENED AND ENDANGERED SPECIES

Canadian Wildlife Service

DISTRIBUTION OF WHALES AND SEALS

DFO

Ducks Unlimited Project Information

Ducks Unlimited

ECOLOGICAL LAND SURVEY (ELS)

Inland Waters Directorate

Environmental Atlas of Coastal Labrador

Environmental Protection, EC

Environmental Atlas of Southeastern Newfoundland

Environment Protection, EC

ENVIRONMENTAL CONTAMINANTS IN SEABIRDS

Canadian Wildlife Service

ENVIRONMENTAL INFORMATION SYSTEM

Statistics Canada

ENVIRONMENTAL INFORMATION SYSTEMS

Inland Waters Directorate

EXPERIMENTAL ECOLOGY DATA - EXPEC

DFO

Experimental Lakes - Chemistry and Aquatic Biology

DFO

EXTRACT AND CRUDE OIL DATA BASE

Geological Survey of Canada

Fish and Wildlife Surveys Within National Parks

Canadian Parks Service

FLOOD RISK MAPS

Inland Waters Directorate

FOREST INSECT AND DISEASE SURVEY DATABASE

Canadian Forestry Service

Forest Meteorology Experiment

Newfoundland Forest Research
Centre

Forest Site Types of Newfoundland

Newfoundland Forest Research
Centre

FRESHWATER AND ANADROMOUS DATA - FAFP	DFO
Geological Map Index of Labrador	Geological Survey Branch
Geology of the Island of Newfoundland	Geological Survey Branch
Geophysical and Geochemical Map Index, Labrador	Geological Survey Branch
GEOSCAN	Geological Survey of Canada
GEOTECHNICAL BOREHOLE DATA	Whitford and Assocs, Halifax
GEOTECHNICAL DATABASE	Atlantic Geoscience Centre
Gros Morne - Biophysical Inventory	Gros Morne National Park
GROUND FISH DATA - GFISH	DFO
GSC FOSSIL LOCALITY DATABASE (FOSSDATA)	Geological Survey of Canada
Heathland Classification of Newfoundland	Forestry Canada
HUMBER RIVER BASIN DATA	Newfoundland Power Company
HYDAT (NATIONAL HYDROMETRIC DATA BANK)	Inland Waters Directorate
Impact of Pesticides on Songbirds	Canadian Wildlife Service
INVERTEBRATE DATA - INVRT	DFO
LABRADOR QUATERNARY DATA FILE	Geological Survey Branch
LAKE SEDIMENT GEOCHEMISTRY	Geological Survey Branch
LONG RANGE TRANSPORT OF ATMOSPHERIC POLLUTANTS - LRTAP	Inland Waters Directorate
MARINE CHEMISTRY DATA HOLDINGS	DFO
MARINE CLIMATOLOGICAL DATA (MAST, CONAN, DUST, SPASM, CRISP)	Atmospheric Environment Service

Marine Environment Datasets MARINE ENVIRONMENTAL DATA SERVICE - MEDS	Ocean Sciences Centre DFO
MARINE MONITORING DATA	Martec Ltd
METEOROLOGICAL AND CLIMATE DATA	Canadian Climate Centre
MIGRATORY GAME BIRD POPULATION STATUS DATA BASE	Canadian Wildlife Service
NATIONAL AEROMAGNETIC DATABASE (NADB)	Geological Survey of Canada
NATIONAL AIR POLLUTION SURVEILLANCE NETWORK - NAPS	Conservation and Protection
NATIONAL AIRBORNE GAMMA-RAY SPECTROMETER DATA	Geological Survey of Canada
NATIONAL ARCHIVE - CLIMATE	Canadian Climate Centre
NATIONAL ATMOSPHERIC CHEMISTRY DATA BASE - NATCHEM	Atmospheric Environment Service
NATIONAL BOREHOLE GEOPHYSICAL LOGS	Geological Survey of Canada
NATIONAL CONSERVATION AREAS DATA BASE - NCADB	Canadian Parks Service
NATIONAL GRAVITY ANOMALY DATA BASE (NGADB)	Geological Survey of Canada
NATIONAL GRAVITY CONTROL STATION DATA BASE	Geological Survey of Canada
NATIONAL HARVEST SURVEYS	Canadian Wildlife Service
NATIONAL MINERAL OCCURRENCE FILE	Geological Survey of Canada
NATIONAL PARKS BIOPHYSICAL INVENTORIES DATA BASE	Canadian Parks Service
NATIONAL REGISTRY OF TOXIC CHEMICAL	Canadian Wildlife Service

RESIDUES

NATIONAL SOIL DATA BASE	Agriculture Canada
NATIONAL WATER QUALITY DATA BASE (NAQUADAT)	Inland Waters Directorate
NEWFOUNDLAND AND LABRADOR GRANITE FILE	Geological Survey Branch
NEWFOUNDLAND AND LABRADOR STREAM SEDIMENT DATA FILE	Geological Survey Branch
NEWFOUNDLAND CARBON14 DATA BASE	Geological Survey Branch
NEWFOUNDLAND DRILL CORE ASSAY DATA	Geological Survey Branch
NEWFOUNDLAND DRILL CORE INDEX	Geological Survey Branch
NEWFOUNDLAND DRILL HOLE MANAGEMENT	Geological Survey Branch
NEWFOUNDLAND MILL TAILINGS ASSESSMENT	Department of Mines and Energy
NEWFOUNDLAND MINERAL OCCURRENCE DATA SYSTEM (MODS)	Geological Survey Branch
NEWFOUNDLAND MINERAL RIGHTS DATABASE	Geological Survey Branch
NEWFOUNDLAND QUATERNARY DATA FILE	Geological Survey Branch
NEWFOUNDLAND QUATERNARY MAPPING DATABASE	Geological Survey Branch
NEWFOUNDLAND SAND AND GRAVEL AGGREGATE DATABASE	Geological Survey Branch
Non-standard climate data sets for Newfoundland and Labrador	Newfoundland and Labrador Climate Advisory Committee
NUTRIENT AND BIOLOGICAL PRODUCTIVITY IN ATLANTIC REGION WATERS	Canadian Wildlife Service
OCEANBASE	Environment Canada

OCEANOGRAPHY DATA - OCEAN	DFO
PALEOECOLOGICAL DATABASE	Geological Survey of Canada
PELAGIC DATA - PELAG	DFO
PIPING PLOVER NESTING SITES	Canadian Wildlife Service
PIROP 1 (Shipboard Surveys)	Canadian Wildlife Service
PIROP II (AERIAL SURVEYS)	Canadian Wildlife Service
PROTECTED WATER SUPPLY AREAS	Water Resources Division
RARE VASCULAR PLANTS OF NEWFOUNDLAND	Jardin botanique, Montreal
RESIDUAL DISCHARGE INVENTORY SYSTEM (RDIS)	Environment Canada
River Ecology - Cape Race	DFO
SHELLFISH LEASE INVENTORY	DFO
SID (SAMPLE INFORMATION DATA BASE)	Atlantic Geoscience Centre
SITE DESCRIPTIONS, FOREST RESERVES	Department of Forestry and Agriculture
STREAMFLOW DATA	Water Resources Division
Succession on Disturbed Forest Land	Forestry Canada
Surficial Geology of Insular Newfoundland	Geological Survey Branch
SURFICIAL MINERAL RESOURCES OFF EASTERN CANADA	EMR
Terra Nova National Park Biophysical Data	Terra Nova National Park
TOXIC CHEMICALS DATA BASE	Inland Waters Directorate
Trans-Labrador Highway Environmental Study	Department of Transport
TREE RING STUDIES IN CANADA; A	Geological Survey of Canada

BIBLIOGRAPHY AND DATA BASE

WATDOC - WATER RESOURCES DOCUMENTATION REFERENCE CENTRE

National Research Council

WATER QUALITY DATABASE (INDEX BASIN NETWORK)

Water Resources Division

WATER WELL DATA

Water Resources Division

Weather Records from Agricultural Research Stations

Agriculture Canada

West Coast - Marine Invertebrates, Inshore Physical Oceanography

Memorial University of
Newfoundland

NUMBER OF DATABASES AND DATA SETS BY MAJOR AREAS OF SPECIALIZATION

Acid Precipitation	9
Agriculture	4
Archaeology	4
Biology	9
Birds	11
Chemistry	39
Climatology	20
Coastal regions	20
Ecology	8
Floristic Studies	5
Forestry	9
Geology	25
Hydrology	18
Oceanography	29
Palynology	4
Rivers	11
Soil	6
Waste Disposal	5
Wildlife	6

APPENDIX 2 - ORGANIZATIONS/PROGRAMS CARRYING OUT RESEARCH AND MONITORING IN OR RELEVANT TO NEWFOUNDLAND AND LABRADOR (FROM TERRAMON DATABASE)

AGRICULTURE CANADA, through its national **CENTRE FOR LAND AND BIOLOGICAL RESOURCES RESEARCH** carries out research on insects, mites, spiders, nematodes, vascular plants and fungi of importance to Canada. Of special relevance to global change are two projects: soil carbon and soil quality evaluation. The soil C component of the Soil Landscapes of Canada (1:1 million) database will provide the information needed to assess the present level of C in Canadian soils and the basic data required for process-oriented models estimating the extent of C fluxes from soils as a result of environmental change. This concerns wetlands over the whole Canadian landmass.

The Soil Quality Evaluation Program consists of the following national studies: (1) soil quality criteria and standards; (2) soil and environmental quality analysis and assessment; (3) land use analysis and monitoring system; (4) soil quality benchmark sites; (5) wind erosion monitoring and prediction; (6) water erosion monitoring and prediction; (7) evaluating soil organic matter changes; (8) soil salinity monitoring and prediction; (9) structure assessment and prediction; (10) predicting the fate of organic and inorganic additions to the soil; (11) land evaluation for agricultural sustainability.

The **ATLANTIC CENTRE FOR THE ENVIRONMENT** is the umbrella for the environmental activities of the Quebec-Labrador Foundation. Its primary concerns are rivers and watersheds, wildlife and habitats, rural landscapes and community development. The Centre runs projects in Central and Northern Newfoundland, and has been active in a recent NOAA project to retrieve tagged salmon in Notre Dame Bay. ACE supports volunteers especially from New England who work on projects in Newfoundland and elsewhere.

ATLANTIC COASTAL ACTION PROGRAM led by the Environment Protection service of Environment Canada, this is a \$10 million effort set up in 1991 under the Green Plan to develop comprehensive environmental management plans for the coastal resources of Atlantic Canada. These plans will link information from environmental quality assessments, the project objectives and remedial measures assessment to devise a long-term strategy, which includes implementing protection and rehabilitation measures. The output will be a series of "blueprints" for managing the coastal resources in 12 areas, including in Newfoundland Humber Arm and St. John's harbour.

An **ATLANTIC PROTECTED AREAS NETWORK** is being planned by Environment Canada and Forestry Canada to look at the current state of protected areas in the region and to develop a Protected Area Network in Atlantic Canada. The background is the contrast between

the Green Plan's recommendation to set aside 12% of the country as protected space, and the current <3% protection in the Atlantic region. The new group is involving others in a discussion of the technical and administrative questions related to this issue. A comprehensive inventory of protected areas is now being compiled.

The **ATMOSPHERIC ENVIRONMENT SERVICE** of Environment Canada conducts widespread weather observations and analysis in Newfoundland and Labrador. AES operates its own stations and gathers data from those run by other agencies such as Agriculture Canada and the Newfoundland Department of Environment and Lands. The latest issue of the AES Climatological Station Catalogue lists 269 existing and past stations in the province. Those stations classed as SYNOPTIC follow WMO standards. Most are institutional but a few are privately run on contract. Some are manually operated, some automatic. At St. John's, Stephenville and Goose Bay airports there are UPPER AIR Stations. These two send twice daily balloons with radios to 100,000 feet or more (until they burst and the radio parachutes) measuring wind speeds, humidity and T. AES apparently considers the present network of weather stations on the Island to be adequate to describe the climate, but new stations can be added where development warrants.

BIOME-TEL is a current research project (1990-1993) on "the implications of climate changes on the Quebec boreal forest and the forest industry." It is applying an ecosystem model integrated with GIS to the boreal forest between 48N and 55N, and apparently extending into Labrador. Input parameters will be regionalized meteorological data and simulations of the general circulation models of AES' Canadian Climate Centre, using an assumed doubling of CO₂. The permanent sampling plots of the Quebec Government will be used to correlate between satellite signatures and vegetation characteristics.

The **CANADIAN WILDLIFE SERVICE (CWS)** is actively engaged in monitoring migratory birds in Newfoundland and Labrador. It controls the Migratory Birds sanctuaries at Terra Nova and the Grey Islands, with another planned for Groswater Bay. CWS has an on-going program of duck surveys, and has been promoting Codroy estuary as a RAMSAR site. CWS manages North American Waterfowl Management Plan activities.

The Federal **DEPARTMENT OF FISHERIES AND OCEANS (DFO)** carries out many research studies in terrestrial lake and river systems as well as at sea. Important among these are a long-term study of aquatic systems biology and physical/chemical observations on three watersheds in Newfoundland: Hardings Pond in Gros Morne National Park, Experimental Ponds (Upper Gander River basin) and Grandy Brook basin. A second long-term study is being carried out on river ecology near Cape Race and Trepassey.

The provincial **DEPARTMENT OF FORESTRY AND AGRICULTURE** has a widespread program of forest studies in Newfoundland and Labrador. This includes monitoring annually in selected areas: forest succession, fire damage, insect and disease; tree mortality and defoliation, and growth and yield of forests. The Forestry Division also manages over 100,000 ha of forest reserves on Crown Lands for purposes of silviculture. These remain under Government control and management until they are ready for harvesting. The program began in mid-1970s and no reserve has yet been harvested. It is estimated that it will take 50 to 60 years for plantations to reach the harvesting stage. Reserves are monitored for growth and yield (via air photos) every year for the first 5 years and every 5 years thereafter. Yearly checks are made for insects. A new program of Permanent Forest Sample Plots is being started to measure growth and yield in systematic way. The Forestry Division makes extensive use of GIS technology.

Faculty members of the **DEPARTMENT OF GEOGRAPHY** at Memorial University are engaged in a number of research programs related to environmental change. These include studies of (1) solar radiation and basic climatic variables in the Mealy Mountains, Grand Lake Basin, and on the Avalon Peninsula, (2) ancient and modern pollen deposition (which shows little change in species composition since beginning of human settlement in Newfoundland), Late Glacial and Holocene history of Avalon Peninsula; lake and offshore sediment cores for correlations between terrestrial and offshore areas; (3) coastal evolution and beach development, and sea-level changes; (4) detection of vegetation patterns in Terra Nova National Park by remote sensing.

DUCKS UNLIMITED CANADA is a private organization which works closely with CWS to create, restore, preserve, and improve prime breeding habitat for waterfowl. Hare Bay is one focus for DU activities in the province.

The **EASTERN HABITAT JOINT VENTURE** is a cooperative effort under North American Waterfowl Management Plan, begun in 1989-90 and led by CWS. The purpose is to maintain and enhance the abundance and quality of wetlands so as to secure the waterfowl resources of Eastern Canada (and by extension the Atlantic and Mississippi Flyways). Areas of interest in Newfoundland are St. George's Bay, Pistolet Bay to Hare Bay, NE Notre Dame Bay, Birchy Basin/Upper Humber, and Eastern Avalon.

The **GEOLOGICAL SURVEY BRANCH** of the Newfoundland Department of Mines and Energy works to establish background values and rates of coastal erosion, sea-level change, slope stability, and groundwater. It has an extensive database on the geochemistry of lakes in Newfoundland and Labrador.

The **GEOLOGICAL SURVEY OF CANADA (GSC)** of Energy, Mines and Resources has many activities relevant to global change, including coastal monitoring in Atlantic Canada and the Beaufort Sea; Quaternary paleoenvironments; geochemistry of soils, rocks and waters in various parts of Canada. The GSC is establishing long-term "global change laboratories" on Ellesmere Island and in the southern prairies. Scientists at the GSC's Atlantic Geoscience Centre (Dartmouth) are conducting long-term studies on selected beaches and coastlines in the Maritime provinces and Newfoundland.

The **INDUSTRIAL ENVIRONMENTAL ENGINEERING DIVISION (IEED)** of the Newfoundland Department of Environment and Lands monitors acid rain (wet deposition: pH, SO₄, NO₃..), airborne particulates, SO₂, ozone, volatile organic compounds, semi-volatile organic compounds (PAH, PCB, PCPP, PCPE) at a small number of sites around the province. Analytical data is contributed to the national NATCHEM database run by AES. IEED also manages sites for local pollution studies in Corner Brook, Come-by-Chance, Holyrood and Long Harbour.

The **INLAND WATERS DIRECTORATE (IWD)** of Environment Canada operates a widespread federal hydrometric network for 16 rivers: streamflow and precipitation; surface water data; historical streamflow data. Some stations are jointly managed by federal and provincial agencies (Water Resources Division of the Newfoundland Department of Environment and Lands).

The **LABRADOR ECOSYSTEMS ANALYSIS FACILITY (LEAF)** is a proposed research facility and research funding agency under MUN-LINS. The overall goal is to "provide incisive, comprehensive, multi-disciplinary, and unbiased scientific research on Labrador ecosystems and natural resources, to incorporate the indigenous knowledge and data bases of Labradorians into mainstream scientific thought, and to aid in the transfer of knowledge and technology back to the peoples of Labrador." Scientific studies to be sponsored and/or supported by LEAF will include inventories and distributions of specific wildlife species (notably caribou), consistent and systematic baseline environmental data collection, special projects and applied research related to resources. LEAF will be a network of 5 nodes (Upper Lake Melville, Labrador West, North Coast, Southeast Coast, and Labrador Straits) linked to MUN in St. John's. Intensive use will be made of computer and telecommunication links. Each node will have a physical centre and a full-time manager.

The **LAND MANAGEMENT AND SOILS DIVISION** of the Newfoundland Department of Forestry and Agriculture has carried out regional mapping of soils at 1:250,000 of whole island except for Northern Peninsula. The Avalon is covered at 1:100,000. Farm lots are now mapped at 1:250 to 1:5000.

The **MODEL FOREST PROGRAM** is a Green Plan initiative of Forestry Canada which is providing major funds for integrated forest research in selected sites across Canada. A large area of central west and southwest Newfoundland has been selected as one of a limited number of national sites. The research is to be carried out by a consortium of provincial, academic and industry organizations.

The **NATIONAL AIR POLLUTION SURVEILLANCE NETWORK (NAPS)** is a national program, with links to acid rain and related work of Industrial Environmental Engineering Division of Department of Environment and Lands. The only NAPS station in the province is at St. John's airport, which monitors ozone, CO, SO₂, and NO_x.

The **NEWFOUNDLAND FOREST RESEARCH CENTRE** of Forestry Canada carries out a wide range of activities, dealing especially with fire and disease history and control of infestations, outside of forests of commercial interest, which are managed by the provincial Forestry Division. Programs include: forest protection research (biomonitoring on plantation pests and diseases), forest resources and environmental research (environmental effects of forest practices, tree and stand growth, regeneration, economic research), and forest development. The Centre manages the provincial ARNEWS plots, part of a national program of biomonitoring, covering all forest ecosystems to assess general forest "health".

The **NORTH AMERICAN WATERFOWL MANAGEMENT PLAN (NAWMP)** is led in Canada by CWS. and Nfld Wildlife Division run a joint Habitat Protection Plan, begun in 1986. Highest priority given to protecting breeding colonies of seabirds. One program now operating is a Black Duck Survey which extends throughout boreal E. Canada and includes 19 plots (each 10 by 10km) in Newfoundland and Labrador chosen randomly (a few in PAs), in which bird counts have been done regularly since 1989, some longer. The survey, which is expanding in scope, is designed to detect a 10% decline over 10 years. Another joint program is the Eastern Habitat Joint Venture - see separate entry above.

The **NORTHERN WETLANDS STUDY (NWS)** was a multidisciplinary study (1989-1991) joint with NASA to assess the importance of northern wetlands as a source and sink of biogenic gases to the atmosphere. Primary emphasis is on CH₄, but fluxes of N₂O, NO_x, VOC, DMS, and CO₂ were also studied. The main site was Hudson Bay Lowland, the second largest continuous wetland in the world. The biological succession over the last 8000 years is represented here along a 100km transect inland from the coast of James Bay. A second field site was in the subarctic/boreal region of Quebec and Labrador, near Schefferville where the wetland is discontinuous (27% coverage). This area was investigated by the NASA Atmospheric Boundary Layer Experiment (ABLE) project.

The **PARKS DIVISION** of the Newfoundland Department of Tourism and Culture manages all provincial parks, including Wilderness and Ecological Reserves and Heritage Rivers. It has extensive water T data for many PAs. Some monitoring of bird populations is now being carried out at Cape St. Mary's and Witless Bay and of vegetation changes at the former.

The **PROTECTED AREAS ASSOCIATION (PAA)** is a St. John's-based non-governmental organization whose goal is to create a system of protected areas for Newfoundland and Labrador. PAA has many activities in the field of environmental education. It commissioned the survey of Newfoundland's protected areas carried out in 1991 by A.R. Berger, which led to the formation of TERRAMON.

The **WATER RESOURCES DIVISION (WRD)** of the Newfoundland Department of Environment and Lands is the major hydrological agency in the province. It has 6 sections: Water Quality, Investigations (floods and disasters), Hydrological Monitoring, Water Rights, Groundwater, and Water Supply. WRD monitors water quality, water quantity, land use, and weather at some 500 sites. It oversees some 200 water supply areas designated for protection purposes. Continuous records are collected at hydrometric stations; daily at weather stations; monthly or longer at water quality stations. The Water Quality Division monitors some 35 river basins around the province, for many chemical, physical and biological parameters, under the terms of a Federal-Provincial Water Quality Agreement. The Groundwater Section does site investigations; long-term groundwater studies, well inspection and data management, hydrogeological mapping, observation wells, groundwater protection.

The **WORLD OCEAN CIRCULATION EXPERIMENT (WOCE)** is a 10 year (1990-2000) research program sponsored by the Intergovernmental Oceanographic Commission (under UNESCO), the World Climate Research Program (World Meteorological Organization) and the International Union of Scientific Union's Scientific Committee on Ocean Research (SCOR). WOCE will observe, analyze and model the global ocean to obtain a working quantitative understanding of its role in the global climate system. A "Control Volume Experiment" to study gyre dynamics will be made east of the Grand Banks. WOCE is developing a very high resolution model of the process of deep water formation in the Labrador Sea. WOCE will also study sea surface altimetry, surface velocity. A section across the Labrador Sea will be occupied at the end of each winter to measure annual changes produced by convection in the Labrador and Greenland seas.

SOME OTHER RELEVANT PROGRAMS, NETWORKS AND ORGANIZATIONS NOT NOW WORKING DIRECTLY IN NEWFOUNDLAND AND LABRADOR

AMIGO (Americas Inter-hemisphere Geo-biosphere Organization) proposes to use the western parts of North and South America to compare and contrast hemispheric responses to global change. In any equivalent program for the eastern edge of the Americas, Newfoundland could play a prominent role.

The **BOREAL ECOSYSTEMS-ATMOSPHERE STUDY (BOREAS)** is a North American program (1990-1996) to study interactions between the boreal forest biome and the atmosphere in order to clarify their roles in global change. Scientific issues: (1) sensitivity of the boreal forest to changes in the physical climate system (model studies indicate greatest warming due to increased CO₂ will occur at latitudes 45-65N, with the most marked effects in continental interiors); (2) C cycle and biogeochemistry in the boreal forest (Is there a large sink for C in the temperate boreal zone, in living tissues or the soils?); (3) biophysical feedbacks on the physical climate system (What changes in ecological functions will be caused by climate change - e.g. albedo, surface roughness, evapotranspiration - and what feedback effects will these have on near-surface climatology?). A major field effort planned for 1994 in two 20 x 20 km sites near the northern and southern limits of the biome at Nelson House, Thompson Manitoba, and in the Prince Albert National Park, Saskatchewan.

A **CANADIAN CLIMATE RESEARCH NETWORK** is currently being set up to stimulate and coordinate climate research in Canada, and to facilitate the exchange of personnel and transfer of information and data towards a next generation GCM (Global Circulation Model). The network envisages a series of nodes to address key research components, each with a critical mass of expertise focused on a particular theme. The first two nodes are to be set up in 1993, with 4 more by 1994. A high-speed electronic data network will be in place by 1994. The Network will establish a Climate Integration and Prediction Centre to apply research results, to simulate future climates under different emission scenarios, and to help in developing limitation and adaption policies. One area of interest is that of ocean-air interactions, another paleoclimatic data with a focus on a 6KBP simulation. (The GSC is the lead agency in this sub-project). Data will be gathered into a central data base from which transfer functions will be developed to check global models.

The Federation of Biological Societies of Canada is developing a **CANADIAN LONG-TERM ECOSYSTEM RESEARCH - CLERP**. This will assess and monitor the biological impact of environmental changes in Canada. It will link with the LTER (Long-Term Ecological Research Network) in the USA, and will require a network of dedicated study sites to serve as baselines for biological surveys. CLERP would study systematics and biodiversity, biogeography, phenology, community ecology, toxicology, parasitology and pathology, and

conservation biology.

CRYOSPHERE SYSTEMS AND GLOBAL CHANGE (CRYSYS) is a new program being planned in 1991 to improve understanding of the interactions between the cryosphere, atmosphere and the oceans and make it possible to monitor and predict physical environmental changes in northern regions using remote sensing techniques (linked to NASA's EOS). The basic research component aims to develop methods to extract geophysical information from satellite observations. Variables to be addressed include sea ice, land ice (including glaciers, ice caps, and lake and river ice), and snow. Various sites will be established in northern Canada to support the remote sensing program.

CURT (CANADA-USSR RESEARCH ON TREELINE) is a proposed project (1992-1996) of global change research along the circumpolar treeline. It will address two major issues: (1) geographic and temporal variations in response of Arctic front and northern treeline to climatic change, and (2) rate or response of treeline vegetation and aquatic ecosystems to climate change. The primary goal is to acquire and analyze Canadian and Russian lake sediment and peat cores for fossil pollen, plant macro fossils, fossil diatoms and sediment geochemistry. One study site has been selected in northern Ungava.

DIVERSITAS (Ecosystem Function of Biodiversity) is a new international program co-sponsored by the International Union of Biological Sciences (IUBS), SCOPE (the ICSU Scientific Committee on Problems of the Environment), and Unesco in 1991. There are three major themes: (1) ecosystem function of biodiversity - to synthesize information for some 13 selected natural systems such as estuaries, boreal forests, and high mountains; (2) origins, maintenance and loss of biodiversity - to synthesize existing knowledge and design new research on biodiversity at intraspecific genetic and populations levels, including speciation and extinction; and (3) inventorying and monitoring biodiversity - to estimate number of species and their distribution. Sites will be chosen from biosphere reserves in selected biomes plus some marine sites.

GCNET is a system developed by the Canadian Centre for Remote Sensing (CCRS) of Energy, Mines and Resources. It provides a centralized directory service to Canadian and international data sets relevant to global changes research, access to the CCRS image inventory browsing facility, and access to the CCRS Bulletin Board system. GCNet links to an international network developed by NASA with nodes in Japan, Britain, Italy, Germany, the USA, Canada. It gives access to a Directory of Data Sources, currently with about 1500 entries, each referring the user to sources of particular information of use to global change researchers in the natural and physical sciences. Sources relevant to social sciences and economics are being added.

The **GLOBAL ENERGY AND WATER CYCLE EXPERIMENT (GEWEX)** is part of the World Climate Research Program (WCRP). GEWEX is an international effort to observe, model and understand cycles of water and energy in the physical climate system. The Mackenzie Basin is being proposed by Canada as one of the main watersheds of interest.

GRID, the GLOBAL RESOURCE INFORMATION DATABASE, is part of Earthwatch, the family of environmental assessment activities with the UN system coordinated by UNEP, the United Nations Environment Programme. GRID aims to provide timely and reliable environmental information and access to a unique international data management service. It uses GIS and satellite image processing systems to collate information from maps, satellite images, aerial photos, and other sources. The key areas of concern to GRID are climate, biological diversity, freshwater resources, oceans and coastal areas, land degradation, and threats to human health and well-being. GRID brings together available data from GEMS (the UN's Global Environment Monitoring System) and other environmental databanks. The different datasets can be overlaid to examine interactions, eg. between climatic and vegetational attributes. The GRID Summary Data Bulletin of August 1992 lists a number of global data sets (mostly at 1:10,000,000 or 1:20,000,000) and many on a national scale.

The **Human Dimensions of Global Environmental Change (HDGEC)** is an international research program being developed by the International Social Science Council in cooperation with the International Geosphere-Biosphere Programme (IGBP). Projects in the planning stages include: (1) Global Omnibus Environmental Survey (GOES) to determine perceptions and attitudes towards environmental issues; (2) impact of institutions on resource use - to determine how resource management decisions are affected by institutions such as land tenure systems, social institutions, and political-decision making arrangements. Projects being planned in close cooperation with "natural scientists" include: (3) land use/cover change - joint with IGBP; (4) coastal zone utilization and management (treating coastal zones as integrated social and economic systems may shed light on the interactions between urban and rural development); (5) Past environmental and social change - to illuminate links between environment and social change in the past, for example by using knowledge of regional paleoclimates to assess potential future socio-economic impacts of climate change.

The **INLAND WATERS, COASTAL AND OCEAN INFORMATION NETWORK (ICOIN)** is a DFO project whose mission is to find better ways of transferring data by improving access to the vast stores of existing spatio-temporal scientific data and other information on Canada's coastal and inland waters needed for decision making. ICOIN is a nation-wide computer information network linking marine and freshwater environmentally-related sources within government, academia and the private sector. The ICOIN Directory will hold information on all the databases, data services and data sources that will be part of ICOIN.

The **INTERNATIONAL GEOSPHERE-BIOSPHERE PROGRAMME (IGBP)** subtitled A Study of Global Change was set up in 1986 by the International Council of Scientific Unions (ICSU) to foster research on global change. Its aim is "to describe and understand the interactive physical, chemical and biological processes that regulate the total Earth system, the unique environment it provides for life, the changes that are occurring in this system, and the manner in which they are influenced by human activities."

In response to 6 fundamental questions, IGBP has set up 6 core projects:

(1) "How is the chemistry of the global atmosphere regulated, and what is the role of biological processes in producing and consuming trace gases?" **International Global Atmospheric Chemistry (IGAC)** core project. This aims to develop a fundamental understanding of the processes that determine the chemical composition of the atmosphere; to understand the interactions between atmospheric chemical composition and biospheric and climatic processes; and to predict the impact of natural and anthropogenic forcing on the chemical composition of the atmosphere. IGAC has been associated with two large-scale boreal projects: ABLE, led by NASA, and NOWES, led by Canada.

(2) "How will global changes affect terrestrial ecosystems?" **Global Change and Terrestrial Ecosystems (GCTE)** core project. Aims to develop a predictive understanding of the effects of changes in climate, atmospheric composition and land use on terrestrial ecosystems and to determine feedback effects to the physical climate system. GCTE is organized into 4 foci: ecosystem physiology, changes in ecosystem structure; global change impact on agriculture and forestry; global change and ecological complexity. GCTE is planning its own Long-Term Ecological Modelling Network (LEMA). Also a new project under development on Land Use/Land Cover.

(3) "How does vegetation interact with the physical processes of the hydrological cycle?" **Biospheric Aspects of the Hydrological Cycle**. This Core Project aims to "improve our understanding of how ecosystems and their components affect the water cycle, freshwater resources, and partitioning of energy on Earth." BAHC has four research foci: studies of water, energy and carbon transfer between soil, vegetation and the atmosphere at patch scales; regional scale studies of land surface properties and fluxes: experiments, interpretation and modelling; interactions among the biosphere, water resources and climate (regional to continental scales); the weather generator project.

(4) "How will changes in land-use, sea level and climate alter coastal ecosystems, and what are the wider consequences?" **Land Ocean Interactions in the Coastal Zone (LOICZ)**, a core project being developed, aims to develop a predictive understanding of the dynamic behaviour of the land-ocean interface, and hence the responses of coastal systems to global change. There are four potential research foci: land-sea exchanges of matter and energy, coastal responses to sea-level change, carbon fluxes and trace gas emissions, and human dimensions of coastal system change.

(5) "How do ocean biogeochemical processes influence and respond to climate change?" Core Project: **Joint Global Ocean Flux Study (JGOFS)**, and Global Ocean Euphotic Zone Study now being developed. JGOFS, which is joint with SCOR, aims to determine and understand on a global scale the processes controlling the time-varying fluxes of carbon and associated biogenic elements in the ocean and to evaluate the related exchanges between the atmosphere, sea floor and continental boundaries. It aims also to develop a capacity to predict on a global scale the response of oceanic biogeochemical processes to anthropogenic perturbations, in particular those related to climate change.

(6) "What significant climatic and environmental changes occurred in the past and what were their causes?" **PAGES - Past Global Changes**. This Core Project aims in "Stream I" to reconstruct the detailed history of climatic and environmental change for the entire globe for the period since 2000 BP, with a temporal resolution that is at least decadal and ideally annual or seasonal. "Stream II" aims to reconstruct a history of climatic and environmental change through a full glacial cycle, in order to improve our understanding of the natural processes that invoke global climatic changes. There are three general research themes: solar and orbital forcing and response, fundamental Earth system processes, and rapid and abrupt global changes. PAGES has a major project on Paleoclimates of the Northern and Southern Hemispheres (PANASH) to establish the commonalities and interrelationships between known climate fluctuations in the two hemispheres. PANASH I will focus first on the past 1000 years, and PANASH II on the timing and phase relationships of environmental changes in the Northern and Southern Hemispheres over the last 150,000 years.

The overall synthesis of these activities is guided by the **IGBP Task Force on Global Analysis, Interpretation and Modelling (GAIM)**. This is responsible for global synthesis of global change research and has broad interactive relationships with all IGBP Core Projects. The "overall aims are to advance the duration and application of comprehensive prognostic models of the global biogeochemical system; and to couple such models with those of the physical climate system." Two initial studies are (1) a 2-way coupling of vegetation and climate models in order to investigate the effect of regional and global climate change on the distribution of terrestrial ecosystems and their sensitivity to the rate of climate change, and (2) a 3-way coupling of carbon cycle models linking land, atmosphere and ocean components so as to investigate the role of biospheric processes in determining the atmospheric abundance of CO₂ and methane.

To meet the data needs of IGBP, a **Data and Information System (IGBP-DIS)** is being set up to address the generic issues of data processing and management for land, ocean and atmosphere systems, in close liaison with GAIM and the Core Projects.

To achieve IGBP's goals a worldwide field program is needed. **START - IGBP Global Change System for Analysis, Research and Training** provides the necessary structure of networks, centres and sites, and to provide training so as to strengthen the much-needed participation of developing countries in global change research. START will address three main scientific issues: (1) "How do regional changes in, for example, land use, industrial practices,

energy production and urbanization alter regional atmospheric composition, the regional water cycle, and local ecosystem structure and function?" (2) "How can such changes within a region or in combination with those from other regions affect biogeochemical cycles and physical aspects of climate on a global scale?" and (3) "How will the ensemble of global change, acting through either direct effects of altered feedback loops, lead to further regional change in the biospheric life support system?" Using a global partitioning of 13 geographical regions, START aims to establish a Regional Research Network within each. The RRNs will strengthen relevant studies on environmental change, develop research that will assess the causes and effects of global change in a regional context, and forecast future changes so that actions may be taken to mitigate or adapt to them. Within each RRN, coordination between participating groups will be achieved through a Regional Research Centre (RRC) linked to Regional Research Sites (RRS). START is focusing initially on Equatorial South America, Tropical Monsoon Asia, and Northern Africa. START is helping to set up an Inter-American Institute for Global Change Research (IAI) with funding from the Global Environmental Facility of the World Bank, UNDP and UNEP.

IGBP is closely linked with mainly members of the ICSU family, such as SCOR and SCOPE. It is also linked to WCRP (World Climate Research Programme of WMO, IOC and ICSU), the Human Dimensions of Global Environmental Change programme of ISSC, Unesco, UNEP, IPCC and GCOS, the new Global Change Observing System being set up by WMO, IOC, UNEP and ICSU.

The **INTERNATIONAL TUNDRA EXPERIMENT (ITEX)** is a coordinated international program to assess the effects of temperature warming on arctic and alpine plant populations by using a network of northern circumpolar sites beyond the altitudinal and latitudinal treeline. At each ITEX site common experiments will be carried out to quantify the potential ecological and evolutionary responses of representative tundra plant populations to the increased growing season temperatures predicted for northern regions. The overall objective of ITEX is to determine the potential of tundra plants to adjust to climate warming through acclimation or through adaption (genetic change) and to partition the effect of climatic warming on key phenological, morphological, and physiological traits into environmental and genetic components. Canada is proposing 5 areas for study: Churchill Northern Studies Centre, Inuvik-Tuktoyaktuk, Baker Lake, AINA Research Station in Truelove Lowland, and Hot Weather Creek on Ellesmere Island.

NBIOME (Northern Biosphere Observation and Monitoring Experiment) is a new national program on the direct and indirect effects of global climate change on the following aspects of Canada's terrestrial ecosystems: disturbance regimes (fire, pests, wind, cutting); vegetation change (succession, growth, reproduction); net flux of greenhouse gases (CO_2 , CH_4 , CO , NO_2) between terrestrial ecosystems and the atmosphere. Science plan being drawn up by CGCP for application for funds to NSERC. Using ground-based measurements and remote sensing techniques, NBIOME will explore the spatial distribution of stored carbon, the annual

change in major carbon pools, and the effects of disturbance, especially as regards forests, peatlands, tundra, agro-ecosystems and interactions across biomes. The work will be closely linked to NASA's Earth Observing System.

The goal of the **WORKING GROUP ON THE LAST INTERGLACIAL IN THE ARCTIC AND SUBARCTIC (LIGA)** is to "define the primary physical-boundary conditions and climatic parameters that characterized the planetary surface at high northern latitudes during the last interglacial (isotope stage 5)", and to develop a better understanding of the land/sea/atmosphere interactions that control the polar environment during interglacials and major climate transitions. LIGA's two major tasks deal with (1) chronostratigraphy - LIGA will develop a protocol for sampling strategies to maximize the chronological information obtained from a variety of terrestrial sites; and (2) data sets - LIGA will compile data for known last interglacial sites for archiving in standard, readily accessible format primary information including flora and fauna and their isotope ratios, sediment characteristics, and magnetic properties.

Finally, there are several US programs that also bear watching. **EMAP** (Environmental Monitoring and Assessment Program) is aimed at specific ecological indicators. EPA appears to be the main actor here. The Ecological Society of America is developing a broad-based research agenda under the heading **Sustainable Biosphere Initiative**, to acquire, disseminate and use ecological knowledge, with priorities on global change, biological diversity and sustainable ecological systems. The US National Parks Service is a active participant in the US Global Change Program with its own **Global Change Research** in key national parks.

APPENDIX 3 - PROPOSED ENVIRONMENTAL INDICATORS FOR NORWAY (Anon, 1992)

CLIMATE

- Emissions of CO₂ and other climate gases globally and in Norway
- Changes in the forest limit for mountain birch
- Extent of ice on the Barents Sea

THE OZONE LAYER

- Total emissions of ozone-depleting substances (CFCs etc.) globally and in Norway
- "Thickness" of the ozone layer
- Dose of UV radiation

HEALTH

- Radioactive load
- Noise (<55db and/or >65db)
- Emissions of one or more of NO_x, SO₂, Pb, VOC, particulates, and values exceeding a selection of threshold values for these substances

EUTROPHICATION (Anthropogenic Origin)

- Emissions of N and P to a primary recipient
- Water quality classes

DIVERSITY OF NATURAL AND CULTURAL LANDSCAPE

- Vegetation belts in the cultural landscape
- Area of "wilderness" > 5 km from RR, road or power transmission line
- Kms of river without regulated water flow (possibly without embankments)

LOCAL ENVIRONMENT (Possibilities for Recreation)

- Existence of "green belts" in urban areas (or # of persons resident close to these)
- Length of accessible beaches (inland and marine waters)

BIODIVERSITY

- Introduction of foreign genetic material
- Number of salmon strains
- Genetic influence on wild salmon
- Endangered species (selected groups/available biotopes)
- Area of 1-4 selected biotopes (eg. Ancient woodland, "indigenous" forest/wetlands/river delta/riparian forest)

CONTAMINATION OF THE NATURAL ENVIRONMENT

- Emissions of 3 selected micro-pollutants (Cd, Hg, dioxins)
- Hg in cod, trout and flounder
- Eggshell thickness in merlin and goshawk

Radioactivity in reindeer

Heavy metals in sediments and/or Hyclomium sp. (Glittering feather moss)

BIOLOGICAL PRODUCTION

Deposition of SO_2 and NO_x

Index: crown density (defoliation)/epiphytic lichens

Index: "healthy" lakes in respect to fish/invertebrates

Changes in the lichen cover (North Norway)

